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The quality assurance support provided to the National Atmospheric Deposition Program (NADP) and to the National Trends Network (NTN) from the period 1984 to 1987 is summarized. This support was provided through a cooperative agreement between the Colorado State University (CSU) and the U.S. Environmental Protection Agency (EPA). The report describes the specific types of QA activities conducted, the development of this support from a historical perspective and the QA reports and QA data summaries generated.

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Quality Assurance Support for the National Atmospheric Deposition Program And National Trends Network Monitoring Activities: 1984-1987

Grant Number CR811600-01

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ABSTRACT

This report is a summary of quality assurance activities in the NADP/NTN monitoring network between the years 1984 and 1987. The report presents the accomplishments of and recommendations for the network.

The recognized accomplishments of the network are implementation of a Quality Assurance Plan, expansion of the network data base, evaluation of the effectiveness of procedures, and intercomparison of data sets with those from other networks.

Recommendations emphasize expansion of the role of the network Quality Assurance Manager and extension of collocated sites with other networks.

The document contains contributions from six NADP/NTN reports, which have been previously released by the Coordinator's office.

This report was submitted in fulfillment of Grant No. CR-811600-01 by Colorado State University under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers a period from 1984 to 1987, and work was completed as of January 1988.

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SECTION 1
INTRODUCTION

Background:

The National Atmospheric Deposition Program (NADP) monitoring network began operations in July of 1978. The Network used, and continues to use cooperating local, state and federal agencies as well as private industry to operate a network of sites according to a single set of protocols. Based on its success in establishing and managing this national program, the NADP additionally agreed to coordinate and manage the National Trends Network (NTN) proposed in the National Acid Precipitation Assessment Plan (NAPAP). Because the NTN had incorporated the majority of the current NADP sites and had adopted the operating procedures and protocols of the NADP network, the resulting cooperative effort became known, in 1983, as the NADP/NTN deposition monitoring network. This combined, cooperative network serves both the National Atmospheric Deposition Program and the National Acid Precipitation Assessment Program (Cowling et al., 1977; NADP, 1978; Interagency Task Force On Acid Precipitation, 1982; Robertson and Wilson, 1985).

The National Atmospheric Deposition Program is unique in its structure and mode of operation because it represents hundreds of interested individuals and many agencies who cooperate voluntarily to operate deposition monitoring sites and to pool data and research efforts under the NADP umbrella. Committees made up of scientists from all the cooperating agencies oversee the various areas of network operations (siting, analytical laboratory, data management and quality assurance) to ensure that network data will continue to be of the highest quality and be available for a wide variety of research needs.

Objectives:

The unique structure, size, and operational characteristics of the NADP/NTN monitoring network often required the development of innovative modifications to existing quality assurance practices. Responsibility for this development has been assumed by each of the cooperating agencies that direct a monitoring network activity (see Table 1). These quality assurance procedures are then reviewed and accepted by the various NADP committees who have responsibility for overseeing each network function.

The adaptation of quality assurance techniques to network practice is, to a large extent, still being performed voluntarily by each of the agencies who have responsibility for running network programs. This practice has been strongly encouraged since it would require considerable effort and expertise to centralize within a single organization. This decentralized approach to quality assurance, however, creates some unique problems of its own.

Since many of the network quality assurance procedures are innovative adaptations of recognized quality assurance practices, much of the network quality assurance documentation has been reported in the scientific literature, at professional and technical meetings or in various agency reports rather than as a standard network operating procedure publication (see Selected Publications). This lack of centralized quality assurance reporting makes documenting the achievement of network data quality goals and objectives difficult. In addition, it makes it difficult to continue some key quality assurance programs once scientific recognition for the techniques has been achieved, and it increases the likelihood that those quality assurance activities that cannot be maintained by a single agency to be overlooked. Finally, decentralized reporting can lead to situations where results from one effort may conflict with another such that no clear picture of data quality can emerge.

Table 1. NADP/NTN Monitoring Network Quality Assurance Activities And Their Sponsoring Agencies

Task no.	Task Name	Operating Agency	Program Name
FIELD SITE OPERATIONS:			
1.	Quality Control of Field Operations	CAL	CAL Site Interactions
2.	Quality Assurance of Field Operations	CSU	Across Site Network Analysis
3.	Systems and Performance Audit of Field Operations	EPA (RTI)	NADP/NTN Site Visitation Program
4.	Quality Assurance Of Site Chemical Analysis	USGS	Intersite Comparisons.
LABORATORY OPERATIONS:			
5.	Laboratory Quality Control	CAL	CAL QA program
6.	Laboratory Quality Assurance	CAL	Interlaboratory Comparisons.
7.	Laboratory Systems Audit	NADP Subcommittee 2	
DATA MANAGEMENT:			
8.	Quality Control of Site/ Chemical Analysis Data through Data Management	CAL	Data Screening and Coding
8.	Quality Control of Site/ Chemical Analysis Data through Data Management	CSU	Data Screening, Coding and Summary Reporting
9.	Quality Control of Data Management	PNL	Acid Deposition System (ADS) For Statistical Reporting
10.	Quality Assurance of Network Data Management	QA Steering Committee	Systems and Performance Audit of the Data Management Program
NETWORK OPERATIONS :			
11.	Performance Audit of Field and Laboratory Chemical Analysis	USGS	Blind Audit Program
12.	Laboratory Quality Assurance	USGS	Interlaboratory Comparisons.
13.	Performance Audit of the Network	CSU	Network Intercomparison's with CANSAP/CAPMoN
14.	Special Studies which assess various components of Network performance	ALL	Published Scientific Research Results
15.	Systems Review of Deposition Monitoring Network	TASK GROUP 4	NAPAP Annual Review
15.	Systems Review of the Deposition Monitoring Network	QA Steering Commit.	IR-7 Annual Review

CAL - Central Analytical Laboratory, Illinois State Water Survey
CSU - Natural Resource Ecology Laboratory, Colorado State University
EPA - Environmental Monitoring Systems Laboratory, Environmental Protection Agency
PNL - Battelle's Pacific Northwest Laboratory
RTI - Research Triangle Institute, Research Triangle Park, NC
USGS - National Water Quality Laboratory, U.S. Geological Survey
Task Group 4 - National Acid Precipitation Assessment Program (NAPAP)
QA Steering Committee - National Atmospheric Deposition Program

Recognizing the need for a more coordinated and thorough quality assurance program, NADP formed a study committee, in 1982, to address this issue. The work of this committee resulted in the development of a Quality Assurance Plan (NADP, 1984) to cover all aspects of network operation and the recommendation that a full time Quality Assurance Manager be appointed to administer this quality assurance program. The desirability of a coordinated quality assurance program was again recognized in the NAPAP Peer Review held in Boulder, Colorado in 1985 (Joyner, 1986)

The purpose of the cooperative agreement, *Support To The National Atmospheric Deposition Program/ National Trends Network Quality Assurance Program*, contract number CR811600-01, was to provide on-going support for the NADP/NTN Quality Assurance Manager. The QA Manager was to coordinate quality assurance activities of the joint NADP/NTN monitoring network, identify and develop new quality assurance programs for the network as necessary, and report on the quality of deposition data being produced by the NADP/NTN monitoring effort.

SECTION 2
ACCOMPLISHMENTS

At the initiation of this cooperative agreement, the NADP Quality Assurance Plan was just being completed, three external quality assurance programs run by the U.S. Geological Survey were underway, EPA was proposing an external site auditing program and NOAA had recently completed a six station network comparison with the Canadian CANSAP monitoring network. The NADP/NTN Monitoring Network had recently reported its 1982 data and a new data depository, the Acid Deposition System (ADS) for Reporting Statistical Summaries, was being created by the Environmental Protection Agency. One quality assurance report issued by the Central Analytical Laboratory (CAL), covered the initial year of the analytical laboratory operation.

Documentation

Although a number of QA programs were in place there was no one location where network QA documentation could be found. Each agency maintained its own documentation. Requests for documentation were directed to the appropriate agency. This same approach was used in documenting network standard operating procedures (SOPs). Because of this decentralized documentation, a great deal of effort on this project was directed towards locating and verifying the documents which outlined the standard operating procedures and quality assurance practices of the network. Although this effort was successful and the network's standard operating procedures can be derived from these gathered documents, a comprehensive publication would be more useful to future data users and most likely benefit current network management. Since, however, documentation was not a primary goal of the initial cooperative agreement, a decision was made early in the program not to repackage or re-write the network documentation -even though the network could clearly benefit by the effort. Our efforts focused more on gathering and completing the documentation necessary to coordinate and evaluate the existing and proposed quality assurance efforts in order that an evaluation of data quality might be made.

- **The identification and gathering of the network documentation is an accomplishment of the Agreement.**

Publications

The implementation of the Quality Assurance Plan started with a cataloging of quality assurance programs that were then currently in use. As each program was identified, it was evaluated to determination which of the goals set forth in the Quality Assurance Plan it addressed and to identify which agency had primary responsibility for its management. The effort resulted in the identification of the primary programs and agencies presented in Table 1. Some of the programs are identified by their formal agency title while others are described only as an activity of the organization.

Concurrently, documentation for each of the programs in Table 1 was requested along with the standard operating procedures (SOP) for the network. This resulted in the identification of many scientific papers, agency reports, professional and technical meeting proceedings and internal agency data sets which documented many of the quality assurance and network standard operating procedures. In some cases the request itself resulted in the production of an agency sponsored scientific paper or report. Some of the more important documents identified are listed in Table 2. Both Table 1 and 2 have been updated to reflect the information gained over the course of the Agreement.

Table 2. NADP/NTN Quality Assurance Related Publications

no.	Type	Publication
FIELD SITE OPERATIONS:		
1.	SOP	Semonin and Volchok, 1979. **Site Selection and Certification, North Central Regional Project NC-141:Atmospheric Deposition** (National Atmospheric Deposition Program).
2.	SOP	Bigelow, 1984. **Instruction Manual: NADP/NTN Site Selection and Installation.**
3.	SOP	Semonin and Volchok, 1978. **Field Observer Instruction Manual, North Central Regional Project NC-141:Atmospheric Deposition** (National Atmospheric Deposition Program).
4.	SOP	Bigelow, 1982. **Instruction Manual: Site Operation.**
5.	SOP	Dossett, 1984. **Aerochem Metrics Precipitation Collector Maintenance Manual.**
6.	SOP	Eaton and Tew, 1985. **Work Plan for Quality Assurance Assistance to The National Atmospheric Deposition Program and The National Trends Network Deposition Monitoring Program.**
7.	SOP	Stensland et al., 1983. **NADP Quality Control Procedures for Wet Deposition Sample Collection and Field Measurements.**
8.	Report	Stensland and Bowersox, 1982. **Evaluation of Dry Wet-Side NADP Samples.**
9.	Report	Schroder et al., 1985. **Comparison of Daily and Weekly Precipitation Sampling Efficiencies Using Automatic Collectors.**
10.	Report	Bigelow, 1986. **Quality Assurance Report: NADP/NTN Deposition Monitoring; Field Operations.**
11.	Report	Schroder and Brennan, 1985. **Precision Of The Measurement Of pH And Specific Conductance At National Atmospheric Deposition Program Monitoring Sites, October 1981-November 1983.**
12.	Report	Schroder and Brooks, 1987. **Results Of Intercomparison Studies For The Measurement Of pH And Specific Conductance At National Atmospheric Deposition Program National Trends Network Monitoring Sites, October 1981-October 1985.**
LABORATORY OPERATIONS:		
13.	SOP	Peden et al., 1979. **Precipitation Sample Handling, analysis, And Storage.**
14.	SOP	Peden et al., 1986. **Methods For The Collection And Analysis Of Precipitation.**
15.	Report/ SOP	National Atmospheric Deposition Program, 1980. **NADP Quality Assurance Report, Central Analytical Laboratory, Jan 1 1979 to Dec 31 1979.**
16.	Report	Peden, 1983. **Sampling, Analytical, And Quality Assurance Protocols For The National Atmospheric Deposition Program.** Sampling and Analysis Of Rain.
17.	Report	Lockard, 1987. **Quality Assurance Report: NADP/NTN Deposition Monitoring, Laboratory Operations, Central Analytical Laboratory, 1978 through 1983.**
DATA MANAGEMENT:		
18.	SOP	Bowersox, 1985. **Data Validation Procedures for Wet Deposition Samples at the Central Analytical Laboratory of the National Atmospheric Deposition Program.**
19.	Report	Stensland and Bowersox, 1985. **Quality Assurance In Acid Precipitation Monitoring Through The Use Of Ion Balance Calculations.**
OVERALL PROGRAM QUALITY ASSURANCE:		
20.	SOP	Cowling et al., 1977. **Plan Of Research For NC-141 North Central Regional Project On Atmospheric Deposition: Chemical Changes In Atmospheric Deposition And Effects On Agricultural And Forested Land And Surface Waters In The United States.**
21.	SOP	Robertson and Wilson, 1985. **Design of the National Trends Network for Monitoring the Chemistry of Atmospheric Precipitation.**

no.	Type	Publication
22.	SOP	NADP Quality Assurance Steering Committee, 1984. **The NADP Quality Assurance Plan.**
23.	SOP	Schroder and Malo, 1985. **Quality Assurance Program For Wet Deposition Sampling And Chemical Analysis For the National Trends Network.**
24.	Report	Brooks et al., 1985. **Interlaboratory Comparability, Bias, And Precision For Four Laboratories Measuring Constituents In Precipitation.**
25.	Report	Schroder et al., 1985. **Precision And Bias Of Selected Analytes Reported By The National Atmospheric Deposition Program And The National Trends Network--January 1980 Through September 1984.**
26.	Report	Schroder et al., 1985. **Quality Assurance Results For Field pH And Specific Conductance Measurements And For Laboratory Analysis, National Atmospheric Deposition Program and National Trends Network--January 1980-September 1984.**

Data Base

In some instances reports and evaluations of network data quality had been made utilizing information which we felt was of lasting importance to future data users. This information included specific chemical analysis values obtained during audits of site chemical analysis techniques, noted deficiencies in siting criteria and sampling equipment and estimates of data completeness calculated during the calculation of seasonal and annual precipitation chemistry data summaries. This information was primarily date-stamped, site specific data values or quality codes which had been summarized into a single network interpretation or report (e.g. Number of sites with malfunctioning collector in 1983). To maintain this information in a more usable way the NADP/NTN data base was expanded. The expansion incorporated information generated by the U.S. Geological Survey's and Environmental Protection Agency's Site Visitation Programs, the U.S. Geological Survey's Intersite Comparison Program and the summary statistics containing the data completeness coding developed by NADP. These data are now fully integrated with the other deposition data available through the NADP/NTN monitoring program and are being used routinely in NADP/NTN Semi-Annual Data Reports of Precipitation Chemistry, in Annual Summary Reports of Precipitation Chemistry and in the ADS data system.

Coordination

The NADP/NTN Quality Assurance Plan summarizes the key components and goals of the NADP/NTN monitoring network's quality assurance program. It recognizes the quality assurance role of the cooperating agencies and provides the guidelines for evaluating the effectiveness of their efforts. The plan further outlines appropriate actions to be taken to ensure that a complete quality assurance program is followed.

It is the responsibility of the Quality Assurance Manager to administer the NADP Quality Assurance Plan. This requires the Manager to maintain a close liaison with the Central Analytical Laboratory; the U.S. Geological Survey's external NADP/NTN audit programs; the data management and publication activities of the NADP/NTN, as administered through the Coordinator's Office; the EPA's Acid Deposition System for Statistical Reporting (ADS); and to maintain a program to monitor the activities at each of the deposition monitoring stations. The QA Manager also works closely with the NADP QA Steering Committee and provides necessary information as appropriate to NAPAP Task Group 4 and NADP committees.

The QA Manager is independent of other program operations, such as network site operations, chemical analysis, data management and publications. He is administratively responsible to the NADP/NTN Coordinator. The QA Manager is also responsible to the Quality Assurance

Steering Committee, which provides technical guidance for the QA program.

The primary coordination efforts have involved attending the frequent NADP Technical and Subcommittee meetings; writing, revising and reviewing NADP/NTN documentation; reviewing agency reports and proposals that utilize NADP/NTN data or documentation; and disseminating quality assurance information to the various NADP committees and scientists. Each of these activities served as a vehicle for obtaining and documenting the quality assurance activities of the network and for encouraging a schedule of evaluating and reporting of quality assurance data.

An additional part of the coordination effort has involved overseeing the Site Visitation Program (see below) and providing administrative assistance to the program's auditors. The Quality Assurance Manager is responsible for distributing the results of the site audits and for initiating corrective action to correct any discovered deficiencies.

- **The coordination of network quality assurance activities between the various participating agencies and NADP committees is an accomplishment of this Agreement.**

Identification and Development of New Quality Assurance Programs

During the three years of this contract four major reviews were undertaken to evaluate the effectiveness of the procedures used in the NADP/NTN monitoring effort and to identify areas were improvements could be made. These included two reviews of the implementation of the Acid Deposition System For Statistical Reporting (ADS) at Battelle's Pacific Northwest Laboratory in Richland, WA, a data review of the site visits sponsored by the U.S. Geological Survey, a systems audit of the the U.S. Geological Survey's Intersite Comparison Program and External Quality Assurance Program, and a systems audit of the data management practices used within the NADP/NTN and ADS program. Additionally, the CAL laboratory operations were reviewed. The Quality Assurance Manger was a key member of each review team.

These reviews and audits:

- Initiated an accelerated delivery schedule of network data to both the NADP/NTN Coordination Office and the Acid Deposition System (ADS) For Statistical Reporting;
- Resolved and clarified differences in data summarization techniques used throughout the program;
- Improved the procedures for validating and coding field information;
- Identified procedures for transferring quality assurance data to the Quality Assurance Manager;
- Helped develop guidelines for the implementation of a permanent Site Visitation Program and;
- Confirmed the high quality of network data.

Summary Reports of these Reviews are included as appendices to this report (see appendices A-C and E). A brief explanation of each review follows.

Review of the ADS Data Depository

In June 1984 Battelle's PNL was visited to review the newly created ADS data handling and reporting procedures. Data reduction algorithims that categorize and compute NADP/NTN record summaries were reviewed to assure consistency with NADP reporting procedures and current NADP committee recommendations. The reviewers included the NADP/NTN Coordinator and the Quality Assurance Manager. Because of this review, the implementation of an improved data base design at the Coordinator's Office was accelerated and data base modifications were implemented at the Illinois State Water Survey's Central Analytical Laboratory (CAL). The new data base design was based upon recommendations made during an NADP committee meeting held in West Point, NY, December 14-15 1983. The new design allows for better record tracking through the 'site - CAL - Coordinator's Office - Battelle/ADS' data pipeline and allows site description information originating with each of the respective data organizations to be consolidated in one place and integrated with existing chemical analysis information.

A second audit was conducted in March of 1986 in conjunction with the NADP audits of the Central Analytical Laboratory and the NADP Coordinators Office. A summary report of this audit is included as appendix A.

Site Visitation Program

During the fall of 1982 and continuing into the spring of 1983, the U.S. Geological Survey sponsored fact finding visits to each of the then operating and proposed NADP and NTN monitoring stations. The visits were well received and served as a valuable snapshot of the quality of NADP site operations. The data from these visits was reviewed, summarized and incorporated into the first of a series of NADP Quality Assurance Reports (Bigelow, 1986). In addition, the review served as a guide for establishing a permanent site audit program.

In June 1984, discussions were held at Research Triangle Park for the purpose of planning a permanent site audit/visitation program for the NADP/NTN monitoring network. Research Triangle Institute (RTI) was selected as the contractor to perform the site audits/visits, and in the fall of 1984 a formal work plan was developed which specified the procedures to be followed during the audit/visit. Three RTI auditors were trained in techniques to be used during the audits and the program began in January of 1985. All of the NADP/NTN sites had been visited by January 1987 and a second round of visits has begun. Each site is to be visited once every three years. A copy of the work plan is attached as Appendix D.

Audit Of USGS External QA Programs And The Intersite Comparison Study.

In September 1985, the NADP/NTN External Quality Assurance Program operated by the U.S. Geological Survey's National Water Quality Laboratory in Denver, Colorado was audited by members of the NADP Methods Development and Quality Assurance Subcommittee. The review focused on the three areas of performance auditing that were then conducted by the USGS laboratory for the NADP/NTN monitoring network. These areas were: *Intersite Comparisons*, which audit pH and conductivity measurements at each field site; *Interlaboratory Comparisons*, which audit all analyses by the NADP/NTN Central Analytical Laboratory along with those by other selected laboratories involved in atmospheric deposition measurements; and the *Blind Sample Audit*, which audits the sample chemistry measurements at both the field and Central Laboratory locations and sample integrity as each sample travels through the NADP system. Suggestions made during the audit were implemented beginning in January of 1986. The suggestions included increasing the frequency of the Intersite Comparisons, distributing the Blind Sample Audit samples more evenly through time, transferring some of the participation compliance responsibilities to the Quality Assurance Manager's office, and making primary audit results of the Intersite Comparison and Blind Sample Audit programs available to the Quality Assurance Manager.

Audit Of NADP/NTN Data Management Activities

In January through March of 1986, the data management practices of the NADP/NTN Monitoring Network were audited by members of the NADP Technical

Committee. The audit included the data management practices at the Central Analytical Laboratory, the NADP/NTN Coordinator's Office, and the ADS data depository at Battelle's Pacific Northwest Laboratory in Richland, WA. As a result of this audit, quality assurance procedures for validating rainfall amount information in network data have improved, the coding of field data quality has been initiated on a much accelerated schedule, and many manual quality assurance checks and data editing procedures have been automated using computer software. In addition, the audit has resulted in an accelerated delivery schedule of quality assured data from the Central Analytical Laboratory to the NADP/NTN Coordinator's Office and the availability of NADP/NTN data in the ADS data depository at a much earlier date.

Review Of The Central Analytical Laboratory (CAL) Laboratory Procedures

A review of the Central Analytical Laboratory's chemical analysis procedures and data transfer protocols was held simultaneously with the data management audit in January 1986. The review confirmed the continued high level of performance that is practiced by this facility, but revealed some concern about the laboratory's moderation in implementing more automated data transcription techniques such as automated instrumentation-data acquisition systems. It was noted however, in both this and the data management audit that only limited progress would be made in reducing overall NADP/NTN data turn-around if the laboratory implemented such systems at this time.

The identification of program deficiencies and development of new quality assurance programs not only requires a thorough knowledge of the program being quality assured, but also requires an awareness of current practices in similar programs and an awareness of new approaches in the application of quality assurance techniques to atmospheric deposition problems. To meet these requirements the Quality Assurance Manager became involved in various scientific groups such as the *Air Pollution Control Association* (APCA), the *American Society for Testing Materials* (ASTM), and the *Unified Deposition Data Base Committee*, a group of United States and Canadian Scientists involved in producing quality assured data for all of North America. The Quality Assurance Manager was also involved with co-located collector studies with various networks and served as a document reviewer for agencies such as the EPA, the Electric Power Research Institute (EPRI) and the USGS.

- **Participation in program audits and reviews, scientific organizations, document reviews and co-located collector studies resulted in the identification and application of quality assurance techniques used in the NADP/NTN Monitoring Network and helped document the overall quality of the Network's approach to deposition monitoring.**

A Site/Data Certification Program

NADP supports the notion that data users should decide the quality level of sites and/or data produced by the program. To this end NADP encourages the development of 'site descriptive information' which may be used by data users to determine the suitability of sites and data for each investigator's individual analysis. It is the preference of the NADP that data users utilize this information rather than a network derived formula for rating the quality of network monitoring stations or monitoring data. Two examples of user derived estimators of network data quality are presented below. The efforts fall into two basic categories.

First, in the course of establishing guidelines for producing annual summaries of NADP/NTN precipitation data, an NADP committee agreed upon a set of completeness and performance guidelines, and criteria that must be met before a site can be included in an annual summary. An almost identical set of guidelines has been developed by the networks' Canadian counterparts. This is not coincidental since some of the NADP committee members including the Quality Assurance Manager, have gone to considerable effort to participate in the formulation of the Canadian guidelines.

The Canadian effort known as the Unified Deposition Data Base Committee has established a second data quality estimator that uses the representativeness of site location as a means of certifying data quality. The representativeness coding is derived from NADP/NTN audit information available routinely in the NADP/NTN Monitoring Network database and the NAPAP 4.0 emissions inventory.

If both of the estimators are utilized in determining data and monitoring station quality, they constitute a reasonable preliminary site and data certification method that can be used by data users. The successful use of this combination of estimators has been demonstrated in a report issued by the Unified Data Base Committee titled *A Unified Wet Deposition Data Base for Eastern North America: Data Screening, Calculation Procedures, and Results for Sulphates and Nitrates (1980)* (Unified Deposition Data Base Committee, 1986) and in an APCA paper by the same title (Lusis et al., 1986). This same combined approach is also used in the ADS data system at the Battelle Pacific Northwest Laboratory.

Though the combined completeness and representativeness estimator is not used by NADP or NTN, the information used to develop the estimator is routinely collected by the NADP/NTN Monitoring program and is available to data users. The data completeness portion is routinely used to classify sites for inclusion in the *NADP/NTN Annual Data Summary of Precipitation Chemistry In The United States*, and the information used to generate the site representativeness coding is used to document and troubleshoot data anomalies.

Network Intercomparisons

Network intercomparisons, where two or more networks operate collectors at a single location, represent an on-going external systems review of the operating policies and data of each network. Since there is no accepted, certified 'Standard Reference Network', the progress of the NADP/NTN Network can only be measured in relation to other similar efforts at jointly sampled locations.

The Quality Assurance Manager participated in a previous intercomparison with Canada and became involved with a new Canadian CaPMoN-NADP/NTN comparison. He also coauthored a proposal for re-establishing the US/Canadian Intercomparison between the NADP/NTN and CAPMoN/CANSAP monitoring networks. Although the proposal was accepted in principle, only limited funding was allocated. None the less a pair of comparison sites began operating in the fall of 1986.

These studies provide a way of determining reasons why NADP/NTN data does or does not compare with other networks' data and helps in establishing guidelines for merging US and Canadian deposition data sets. An example of information available from such comparisons is contained in a paper presented at the APCA/ASQC Specialty Conference on Quality Assurance in Air Pollution Measurements in October of 1984 in Boulder, Colorado. The paper begins to summarize the data collected during the first intercomparison study which ended in April 1984. The paper is included in the published transactions of the conference (Bigelow et al., 1985).

In addition to the Canadian intercomparisons, intercomparison data sets with other networks were identified. Some of these intercomparisons are listed in Table 3.

Table 3. Co-location of NADP/NTN Sites with Other Networks

Site Name	Location	Network
Bondville	Illinois	MAP3S
Caribou	Maine	CANSAP
Charlottesville	Virginia	MAP3S
Clinton	Mississippi	UAPSP
Douglas Lake	Michigan	CANSAP
Finley	North Carolina	UAPSP
Fernberg	Minnesota	APIOS
Giles County	Tennessee	UAPSP
Glacier National Park- Fire Weather Station	Montana	CANSAP
Kejimkujik National Park	Nova Scotia	CANSAP
Lethbridge	Alberta	CANSAP
Mount Forest	Ontario	CANSAP
Mount Forest	Ontario	APIOS
Oxford	Ohio	MAP3S
Penn State	Pennsylvania	MAP3S
Sutton	Quebec	CaPMoN
Tanbark Flat	California	California-ARB
Underhill	Vermont	UAPSP
Walker Branch Watershed	Tennessee	MAP3S
Whiteface Mountain	New York	MAP3S

Table 4. Proposed Schedule For NADP/NTN Quality Assurance Reports

Summary Period	Report Name	Contributing Agencies	Proposed Completion
1978-1983	Field Operations	CSU	Completed
1978-1983	Laboratory Operations	CAL/USGS	Completed
1978-1983	Data Management	CAL/CSU/ADS	JUL 1986
1978-1983	Network Operations	CAL/USGS/CSU/USMA	JUL 1986
1984	Field Operations	CSU/RTI	MAR 1986
1984	Laboratory Operations	CAL/USGS	MAR 1986
1984	Data Management	CAL/CSU/ADS	OCT 1986
1984	Network Operations	CAL/USGS/CSU/USMA	JAN 1987
1985	Field Operations		JAN 1987
1985	Laboratory Operations		JAN 1987
1985	Data Management		JAN 1987
1985	Network Operations		MAR 1987
1986	Comprehensive Report ???		MAR 1988

Reports Evaluating the Quality Of Data From The NADP/NTN Monitoring Program

In July 1985 a schedule of Quality Assurance Reports was proposed. The reports and schedule were developed recognizing that quality assurance reporting had traditionally been the responsibility of each program contributor to the NADP/NTN monitoring network and that the reporting of quality assurance data had been carried out in the past through the publication of scientific journal articles, meeting proceedings, agency reports and the like. The schedule, presented in Table 4, has not been met and now serves as a future goal. Two of the reports (the first two) have been issued and are included as attachments to this report.

In addition to reviewing the quality assurance report authored by Lockard (1987), the Quality Assurance Manager,

- **Authored one 5 year quality assurance report,**
- **Extensively revised one NADP/NTN Instruction Manual,**
- **Co-authored two NADP/NTN annual data reports,**
- **Co-authored two Unified Deposition Data Base Committee Reports and,**
- **Presented four papers at scientific meetings, three of the presentations are or will soon be published as proceedings.**

Presentations, Reports and Publications are listed below.

Bigelow, D.S., 1984. *NADP Instruction Manual: Site Selection and Installation.* National Atmospheric Deposition Program, Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO. July 1984.

Bigelow, D.S., Still, M.E., Bowersox, V.C., 1985. *Quality Assurance Considerations For Multiple-Network Data Comparisons.* Transactions of the APCA/ASQC Specialty Conference on Quality Assurance in Air Pollution Measurements, Boulder, CO., APCA, Pittsburgh, PA. October 1985

Bigelow, D.S., 1986. *Quality Assurance Report: NADP/NTN Deposition Monitoring, Field Operations 1978 through 1983.* National Atmospheric Deposition Program. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO.

Bigelow, D.S., 1986. *The Use Of Ingres By The National Atmospheric Deposition Program.* Presentation to the Colorado Ingres Users Group. Denver, Colorado, July 22, 1986.

Bigelow, D.S., 1986. *Colorado Data Available Through The National Atmospheric Deposition Program.* Presentation at the CIRA Workshop On Acid Deposition, Pingree Park, Colorado August 14, 1986. (Proceedings to be published)

Bigelow, D.S., 1986. *Regional Influences On Siting And Sampling In The National Atmospheric Deposition Program/ National Trends Network Monitoring Program.* Presentation at the EMEP Workshop On Data Analysis and Presentation, Cologne, West Germany. June 15-17, 1987.

Lockard, J.M., 1987. *Quality Assurance Report: NADP/NTN Deposition Monitoring, Laboratory Operations, Central Analytical Laboratory, 1978 through 1983.* National Atmospheric Deposition Program. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO. May 1987.

Lusis, M.A., Chan, W.H., Voldner, E.C, Vet, R.J., Olsen, A.R., Bigelow, D.S. and T.L. Clark. 1986. *A Unified Wet Deposition Data Base For Eastern North America: Data Screening, Calculation Procedures, And Results.* 79th Annual Meeting of The Air Pollution Control Association. Minneapolis, Minnesota. June 22-27, 1986. 86-29.1.

National Atmospheric Deposition Program, 1985. *NADP Annual Data Summary: Precipitation Chemistry In The United States, 1982.* Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO.

National Atmospheric Deposition Program, 1986. *NADP Annual Data Summary: Precipitation Chemistry In The United States, 1983.* Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO.

Unified Deposition Data Base Committee. 1986. *A Unified Wet Deposition Data Base For Eastern North America: Data Screening, Calculation Procedures, And Results For Sulphates And Nitrates (1980).* Report to the Canadian Federal-Provincial Research and Monitoring Co-Ordinating Committee. 120pp.

Unified Data Base Committee. 1986. *A Unified Wet Deposition Data Base For Eastern North America: Addendum With Results For Sulphates And Nitrates (1980- 1983).* Report to the Canadian Federal-Provincial Research and Monitoring Co-Ordinating Committee. 406pp.

SECTION 3
RECOMMENDATION

The NADP/NTN Monitoring Network appears to be achieving its goals of producing high quality long-term data of precipitation chemistry. This goal was first outlined in planning documents (NADP, 1978: Cowling, 1977; Interagency Task Group On Acid Precipitation, 1982) and reaffirmed with the issuing of the NADP Quality Assurance Plan (NADP, 1984). However, prior to the publication of the two recently issued quality assurance reports (Bigelow, 1986 and Lockard, 1987) evaluations of network quality were difficult to make. Information presented in the QA reports demonstrates the quality of data produced by the Network for the period 1978-1983. Future reports should verify the quality of network data in subsequent years. The lack of a concise standard operating manual and the incomplete quality assurance reports which cover the data management practices and overall network operation, still make it difficult to document the operation of the network.

Although an effort could be mounted to rewrite the NADP/NTN network documentation, the resulting document would be difficult to keep up to date. Furthermore, if the cooperating agencies perceived the document as difficult to use or update, or perceived it as diminishing their responsibility for maintaining quality assurance activities, a valuable contribution to the NADP and NTN programs might be lost. Such an effort would no doubt also duplicate EPA's so called 'Red Book' (Topol et al., 1985) and possibly other agencies manuals. The documentation now compliments these efforts.

Now that there is a coordinated effort to gather and archive Network documents the evaluation of data quality should become less difficult. The quality assurance reports and other selected agency publications are beginning to document data quality and present it to the scientific community in a more usable manner.

- An official depository of standard operating procedures, along with a complete bibliography of these documents should be maintained by the Quality Assurance Manager. The bibliography of network documentation should serve as the primary network documentation.
- The Quality Assurance Manager should continue to evaluate and document network data quality and network procedures through the publication of quality assurance reports. The reports should be inclusive of all years of operation through current time. Adequate funds should be made available to the NADP/NTN program for the publication of these reports.

The Quality Assurance Manager's role in the various NADP committees and in scientific organizations involved in deposition research has enabled him to obtain and reconstruct the quality assurance record of the network and maintain a liaison with those responsible for producing the bulk of this information. Furthermore, the scientific setting has allowed the QA Manager to be come a cooperator and coordinator rather than an antagonist -the traditional role of quality assurance officers. The continued participation in these efforts along with a reasonable number of system audits is important if the decentralized documentation of network quality continues.

- The Quality Assurance Manager's participation in auditing, document reviews and scientific meetings should continue to be supported. These are the windows through which the QA Manager can view the network operations.

Co-located station comparisons between NADP/NTN and other networks as well as between side-by-side equipment within the NADP/NTN network need to be expanded. NADP/NTN has become the reference for deposition monitoring in North America, yet estimates of network precision and bias are still inconclusive. Historical data need to be reviewed and new co-located station programs need to be initiated so that these estimates can be made. Emphasis should be placed on comparisons between the networks' data rather than between the networks' protocols (e.g. daily vs weekly sampling, laboratory A vs laboratory B, etc.)

- A quality assurance program specifically designed to estimate network precision and bias should be developed and implemented as soon as possible.
- The comparability of NADP/NTN data to that of other major networks operating in North America should be established.

SECTION 4
A Review of Data Management and Quality Assurance Procedures used by the Acid Deposition System (ADS) for Statistical Reporting

18-19 March 1986

W. W. Knapp, chairman
D. S. Bigelow and B. A. Malo, members
H. Sauls, observer

Summary of Findings, Comments, and Recommendations

Background

The primary focus of this review is the accuracy, completeness, and timeliness of NADP/NTN wet deposition data available through the ADS data base which is operated by Battelle Pacific Northwest Laboratories of Richland, Washington. ADS is funded by the U.S. Environmental Protection Agency for the purpose of aggregating, integrating and disseminating atmospheric deposition data collected by NADP/NTN and other North American deposition monitoring networks. This review considers only those facets of ADS data processing and management activities which impact the reporting of NADP/NTN wet deposition data. This is the third and concluding review in a series, conducted this year, which examines the processing and management of network sample data from the time of its arrival at the Central Analytical Laboratory through its ultimate dissemination to scientists and other users.

Staff and Facilities

At the time of this review, the staff of ADS consisted of Anthony R. Olsen, project leader, and Antonia L. Slavich. Mr. Olsen devotes 50% of his time and Ms. Slavich 90% of her time to the ADS project. Reviewers were briefed in depth by staff members and provided with a complete set of project documentation. Examples of documents furnished include: an ADS network documentation outline, a system documentation draft, ADS data base schema and structure listings, and examples of ADS standard data reports.

The staff of ADS are members of the Statistical Information Sciences Section of Battelle PNL which has a total staff of about 25. The Statistical Section owns and operates a DEC VAX 11-780 computer, one of several similar machines at Battelle, which is used by its staff as well as by staff members of the Biology and the Chemistry Sections of Battelle PNL. Most computing work associated with the ADS project is done on this machine. Primary and secondary data files comprising the ADS data base at the present time nearly fill a 250 MB removable hard disk pack. This disk pack must be mounted whenever ADS data is processed.

Software use to support the ADS consists primarily of general purpose commercial products along with standard utility programs provided with the DEC VMS operating system. DATATRIEVE, a data base management package, is used to manipulate, store and access chemical deposition and ancillary information files. DISSPLA, a high level graphics program, and SAS, a widely used statistical package, are available and used to summarize and create graphical displays of network data.

Network Data Transfer Procedures

The several contributing networks pass their deposition and most ancillary data to ADS via digital magnetic tapes. Until recently, NADP/NTN data tapes were automatically passed monthly but are now supplied only at the request of ADS staff; typically at quarterly intervals. The data tapes contain two types of files, one that consists of site identification information, and another that consists of network sample data. The files passed contain both new, never-before-passed information, and corrections to previously transferred data. Corrected sample record and/or individual site records are passed in their entirety. No partial record corrections are passed to ADS.

Newly passed records are integrated with the appropriate, existing ADS data file to create complete, up-to-date versions of the two types of data files. Following each update, the network-specific data files are "translated" into corresponding, ADS/DATATRIEVE-format, network-integrated, data files. Because ADS maintains up-to-date source files of all primary data in its original, network-specific format, it serves as an important and independent backup for the original network data bases. Most historical, non-chemical site and general network information, e.g., site moves, changes in equipment, changes in methodology, etc., are transferred to ADS in hardcopy form. Data transfers from other contributing networks are handled in a similar manner. There is, however, an important difference in the frequency with which new data is passed to ADS by the different networks. The following table summarizes the status of chemical deposition data in the ADS data base at the time of the review team's visit:

Network	Latest Data Available: in ADS	from Network	Next Anticipated Data Addition	No. of Sites in Network
MAP3S	DEC 84	DEC 84	DEC 85 in NOV 86	9
NADP/NTN	DEC 84	JUL 85	AUG 85 in APR 86	213
UAPSP	DEC 84	DEC 84	JUN 85 in APR 86	22
APIOS	DEC 83	DEC 83	DEC 84 in MAR 86	48
APN	DEC 82	DEC 82	DEC 83 in APR 86	9
CANSAP	DEC 83	DEC 83	DEC 84 in APR 86	56
CAPMoN	NONE	NONE	DEC 84 in APR 86	24

Quality control of the data transfer process presently consists of : 1) Checking for data integrity errors associated with the reading of magnetic tapes, 2) checking for a lack of error messages associated with the loading of the data base management system, e.g., messages such as; "cannot read record #__", "field is too wide", etc., and 3) checking for overlaps or discontinuities in the serial time sequence of site sample records. Errors or inconsistencies encountered in the transfer process are reported to the source network and reconciled by manual cross checking.

Comments and Recommendations

Review team members recognize and support the purposes of establishing and maintaining an integrated, multi-network, data base of North American atmospheric deposition data. We were particularly impressed that this unified data base system has been developed and documented so quickly with such a modest number of staff. Credit for this accomplishment is due in no small measure to Tony Olsen's skill and effort in gaining the confidence and cooperation of the principals involved in operating the major deposition monitoring networks.

The reviewers offer the following specific comments and recommendations which are intended to help maintain or improve the quality of data and services provided by ADS:

1. Expand Staff and Increase Computer Disk Storage Capacity

Substantial expansion of the ADS data base is planned to occur in the next year. Presently, the ADS data base contains wet deposition chemistry data from seven major North American monitoring networks. In the coming year wet deposition data from 17 sites in the State Operated Network sponsored by EPA regional offices will be added along with data from about 120 more sites from 4 other state and federally supported regional networks.

An increase in staff and greater computer disk storage capacity will be needed to handle the expanded work load and data base size. Tony Olsen is well aware of the need for additional staff and is presently seeking an additional full time staff member to process user data requests (8-10 per month at present) and carry out routine maintenance of the existing data base. This will allow current staff members time to plan and implement procedures necessary to assimilate data from new networks, develop new or enhanced data reports and summarizations, and keep ADS system documentation up-to-date.

Reviewers believe that present computer disk storage resources available to ADS are inadequate to support the future growth of existing data files let alone provide for the planned addition of data from several new networks. Because of limitations in the DATATRIEVE software that concern managing data files which exceed the storage space available on a single disk volume, it is likely that ameliorating this situation will require Battelle to acquire a very large capacity hard disk drive which can be dedicated to ADS data base on-line storage. We recommend that immediate steps be taken to procure the necessary storage hardware to handle anticipated ADS data base growth and expansion over at least the next 2-3 years.

2. Augment Quality Control Procedures

From all evidence available to the review team, the accuracy of NADP/NTN data reported by ADS is essentially equal to that of the site sample data on a data tape of comparable vintage available from the network Coordinator's Office. This observation may be taken as an indication that existing quality control checks used in conjunction with ADS data transfer, translation and retrieval procedures are adequate. Nevertheless, while the QC checks presently used are appropriate and should be continued, the reviewers believe that quality assurance could be significantly strengthened by adding two simple QC procedures. We recommend that, in all transfers of data from any network to ADS, a quantitative measure of the total amount of data being transferred (e.g., number of records or bytes) be supplied along with the data files. This figure should be verified by ADS staff at the completion of the transfer process. We further suggest that the accuracy of all data records transferred to ADS be verified by comparing 1-2% of the transferred records with records transferred by some independent means such as paper records, electronic mail, etc.

3. Process Data Additions and Revisions on a More Frequent Schedule

Of the seven North American deposition monitoring networks currently supplying data to ADS, only the NADP/NTN and the UAPSP networks provide updates more frequently than once per year. NADP/NTN can and, until recently, did pass data additions and revisions to ADS monthly. This practice has been discontinued, however, because ADS has adopted the philosophy of updating its primary data files on an annual basis to match the annual frequency of data transfers provided by the majority of networks contributing data to it.

Review team members appreciate the difficult position of ADS staff in trying to satisfy users wanting the most up-to-date data available while having to rely on voluntary submissions of primary data from network sources. Even in its present size and form, a significant amount of staff effort and computing time is required to do a complete update of files in the ADS data base. It is therefore reasonable for ADS to adopt a schedule of data base updating which takes into account the frequency at which most network contributors are able to pass data additions and revisions.

However,it is apparent to the review panel that an annual schedule of updating the ADS data base is not adequate to meet the needs of some users. Moreover, it gives a false impression to ADS users that NADP/NTN data is not available in as timely a fashion as it actually is. We therefore recommend that ADS try to accommodate network data additions and revisions at quarterly or more frequent intervals and that sponsors and operators of all contributing networks be encouraged to meet this schedule.

SECTION 5

Committee Report on External Q/A Program
Department of Energy
Environmental Measurements
376 Hudson Street
New York, New York 10014

COMMITTEE REPORT ON EXTERNAL Q/A PROGRAM

A review group composed of the following individuals, Van Browesox, Gerald Aubertin, John Robertson, David Bigelow, Jerry Byers, and Donald Bogen, visited the U.S. Geological Survey on Sept. 13, 1985. The purpose of our visit was to conduct an overview of the G.S. external Q/A program for the NADP/NTN precipitation chemistry network and to make recommendations for possible improvements or expansion of the present program.

Leory Schroeder, who heads-up the G.S. program, was our host and provided all the information in our discussions. Due to time constraints of some members of the review group we were able to cover only the exisiting program and, consequently, there was no discussion as to other areas of the network operations which would benifit from implimenting a external audit program. Listed below is a summsry of the review committee activities for the day and recommendations for the program.

1. Leory Schroeder opened the discussions with an overview of the U.S. Geological Survey's contribution to the Q/A program for the NADP/NTN precipitation chemistry network. He defined the Geological Survey organizational structure and the man-years about (1.4) of effort expanded on the program. He reviewed his statutory requirements to NTN and the linkage to the NADP operations.

Next, Leroy provided a description of the mechanics of the three part program, as performed at his lab. The first part of the program, Intersite Comparison, is conducted quarterly to evaluate how well each site performs pH and specific conductance measurements. Samples are prepared, certified, distributed to the sites, the results returned and tabulated at the G.S. One report for the time period, October 1981-November 1983, summarizing site performance, anonymously, has been issued. Annual reports will be issued in the future as part of NTN reporting requirements.

The second part of the program is the CAL blind audit program reference samples, measured and certified by the G.S., are sent to specific sites in the network. When there is no rain for a week, a portion of this reference sample is placed about (400 ml) into a clean bucket, field measurements performed, and then the bucket is shipped to CAL as a routine weekly sample. The remaining portion of the reference sample is shipped back to the G.S. and then transhipped to program manager, G.Stensland, at CAL. The program manager then inserts the sample into the sample flow as a blind. At the present time about 50-60 samples are analyzed per year as part of this program. Leroy said that when the program was initiated until the present time the ion concentration levels in the reference sample were much higher than the typical rain sample. Now, new reference rain water samples from EPA were being introduced into the samples flow to overcome this problem.

The third part of the program is an interlaboratory comparison program which includes four laboratories, Canadian Inland Waters, CAL, G.S. Atlanta and G.S. Denver. The purpose of this program is to provide bias and variance estimates of the analytical methodology used at each lab. These data can be used for merging Canadian and CAL derived precipitation chemistry network data. These intercomparison are performed on a quarterly (?) basis. Leroy has completed a report summarizing the laboratories results which is undergoing internal review at the G.S. and he expects publication before the end of the calender year.

Next we went on a tour of the Q/A laboratory and then reviewed all the hard copy records maintained at the G.S. relating to this program.

The review group then met without Leory for discussions and a list of the recommendations for enhancing or modifying the program was developed. These recommendations are provided below for each component part of the program.

A. INTERSITE COMPARISION- Field Site Audits

The review group was very satisfied with the scope, frequently and performance of the intersite comparision program. Specific proposals for enhancement are:

1. A due date for submission of data should be specified in the letter sent to the sites.

2. Also, when the letter is sent to the sites, a copy of the NADP/NTN policy statement concerning non-compliance should be attached.

3. After completion of a quartely test, the U.S.G.S. will provide a list of all non-participating sites to the Quality Assurance Manager, Dave Bigelow. The quality assurance manager will then contact these sites to determine the cause of non-compliance.

4. The letter sent back to sites after completion of the quarterly test should contain the sites results in addition to the reference values.

5. Also, in the letter to sites which includes the graphical presentation of all site performance, please add a 0.1 pH unit box in addition to the 1.5. sigma box.

6. Results for the quarterly tests should be fowarded to the Q/A manager about ~~every six~~ months.

7. Further analysis of the previous tests should be performed. We have not formulated what type of analysis should be done and are subject to further discussion.

8. CAL who performed the intersite comparisions from 1978-1981 should issue a report summarizing all data as soon as possible.

B. CAL BLIND AUDIT

The blind audit program represent an overall assessment of data quality since all components, field handling, transport, CAL handling, and analytical measurement, of network operations are evaluated. Specific comments are:

1. It would be better if the sites choosen to participate in submission of sample had better geographically distribution. In addition, attempts should be made that samples submitted in this project do not arrive simulataneously so that results generated at CAL are produced on a regular time basis.

2. Samples prepared at the G.S. should be acidified immediately after preparation instead of prior to shippment to the sites.

3. There was some concern expressed about the use of high ion concentration reference samples for use in bias and variance evaluation. The new reference samples from EPA should eliminate this concern and provide more realistic estimates of bias and variance.

4. No samples containing H^+ and NO_3^- have been available for this program. This is considered a serious problem since the network is designed to assess variations in acidic loading and acid forming species. The recent introdution of the pH-4.3 nitric acid check solution as one of the reference samples will help to overcome this defeciency. It should be cBonsidered in the future to have other acid reference samples available containing the full suite of ions analyzed in the program.

5. Presently, about 50 samples are analyzed annually. We recommend that the number of samples passed through the system be doubled. This increase would represent about 1% of the sample through put for the entire network.

6. We recommend that data generated by this program be submitted to the Quality AssuranceB manager on an annual basis.

7. We recommend that further data analysis of the CAL blind audit program be performed. As previous specified we have no recommendations, at the present time, as to what type of analysis should be performed.

C. INTERCOMPARISIONS LABORATORIES

1. This program is operating excellently and we suggest that the G.S. consider adding other labs involved in network operations, ie. MAP3S, etc, be enrolled in this program. This would allow for credible merging of various network data bases.

2. We recommend the G.S. perform an annual summary of the CAL performance in the intercomparision studies indicating analytical measurements biases and variances.

D. OTHER COMMENTS

1. We recommend that the G.S. provide a statement on CAL performance, both to network (blind audit) and laboratory (Intercomparision), which can be incorporated into the annual NADP/NTN quality assurance report.

Don Bogen, Chemist
Analytical Chemistry Division

SECTION 6
Review of the Data Management Procedures and Data Quality Assurance Programs at the Central Analytical Laboratory and Coordinator's Office
6-9 January 1986

J. K. Robertson, Chairman
D. Bigelow, V. Bowersox, and J. Lynch (members)
J. Gibson. G. Byers, and P. Kapinos (observers)

Summary of Findings, Comments, and Recommendations

This committee was tasked to review the data management procedures of NADP/NTN in the face of criticism that data from the network was slow to appear in the public record. At the same time, the committee was asked to follow up on a similar quality assurance effort accomplished in April 1984.

The objective of this review was to examine each step of the NADP/NTN data path from the initial processing of the sample buckets at the CAL through the production of final network data tapes. Production of printed data reports and interpretive data reports were not the subject of this review and were left to subcommittee #3 for review. At the time of this review, elements of the CAL had only recently (2 mos.) moved into new quarters. In addition, the recent holiday period had caused minor delays in data processing at both the CAL and Coordinator's Office. These delays were discounted in ascertaining data age at each step in the data review process.

At the time of this review, quality assured data through February 1985 had been passed to the NAPAP repository at Pacific Northwest Laboratory. This committee notes that the recent National Academy of Science Committee on Monitoring and Assessment of Trends in Acid Deposition, chaired by Dr. James Gibson, has not found any precipitation chemistry data set in the literature whose data quality could be ascertained with sufficient clarity to allow its use in determining long-term trends in precipitation chemistry. This is a result of collection, analytical, and data screening procedures not being documented sufficiently. NADP/NTN has been aware of the shortcomings of old data sets and has sought from its beginnings to provide a long-term data set in which each data point was carefully evaluated for its relevance in relation to carefully documented network protocols. The available NADP/NTN data set presents all data collected by the network with screening codes which alert the user to instances where data collected are at variance with network protocols, and identifies samples which have become contaminated. Other networks are developing and adopting procedures to produce verified and validated data analogous to those of NADP/NTN. This committee finds that the screening performed by the Central Analytical Laboratory and the Coordinator's Office is necessary to provide current and future data users with data whose quality are determinable. **NO CHANGE SHOULD BE MADE THAT REDUCES THE SCRUTINY EACH DATA POINT CURRENTLY RECEIVES.** This is not to say there is no room for improvement in current procedures.

The review committee was given flow chart outlines of procedures, which they then followed by interviewing each participant in the process. Since the April 1984 review, procedures have evolved in a way consistent with that committee's recommendations--there is increased emphasis on reduction of manual procedures. In addition increased use of microcomputers tied to mainframe databases is in evidence. This transition is ongoing. It is important to note that there has been little turnover in key personnel at both CAL and the Coordinators Office. We still see the dedicated, competent personnel enthusiastically pursuing the production of quality data. Data screening procedures are better documented at both locations, but a single Standard Operating Procedure containing the set of decision rules that cause a sample to be flagged a particular way does not exist. These documents are still needed as suggested by the April 1984 committee.

The committee makes the following comments and specific recommendations which it believes will maintain the quality of data now produced, but will further reduce paper-based data handling and speed the production of final quality defined data:

1. The availability of clarifying data from the site was determined to be a key element in deciding whether sampling protocol (SP) or screening level (SL) codes were assigned to a sample. There are two aspects of this which may improve the availability of clarifying data:
   a) the review committee notes that many of the problems could be solved by the presence at CAL of a copy of the weekly raingage chart. In 1983 the CAL Review Team and in 1984 the Data Quality Assurance Review Team endorsed having every site submit a weekly rain gauge chart with their weekly sample. Subcommittee #1 has had the Coordinator's Office conduct a survey of site attitudes towards this procedure. We recommend subcommittee #1 study proposals to implement this procedure with specific attention to cost, effect on the quality

assurance now performed by the site, additional storage and handling procedures needed at CAL, protocol to be followed at CAL (i.e., store and use only to resolve problems; read every chart to verify field form data; digitize and obtain more data) and make recommendations to the NADP Executive Committee in May 1986.

b) Liaison with the sites is now centered with the CAL Site Manager. Recently the person performing the final data reviews has begun some site contact. The committee feels that one person contacting sites as the focal point is better than many. The committee notes the backlog of contacts that the Site Manager has been unable to make. The committee also notes that the Site Manager's time is not fully devoted to site liaison activities. We recommend that consideration be given to reducing his non-site liaison activities. This newly available time should be used for telephone contact in resolving problems that hold up determination of screening level codes and may delay data passage.

2. The committee recommends that data be entered into the system sooner than current practice, using computerized data files and programs to perform as much editing/checking as possible to reduce manual editing and the tremendous reliance on paper now in evidence. In this regard, networking of current personal computers to allow sharing of data files instead of duplication of data files with eventual adoption of multi-user applications is encouraged.

3. The committee notes that CAL is currently meeting, for the most part, its goals for production of the field printout, preliminary data report, and transmittal of tapes to the Coordinators Office. The committee endorses the current practice of monthly transfer of data, but the committee feels that the CAL targets are not as tight as they could be. Therefore, we recommend that CAL undertake a review of its procedures, manpower allocations, etc. with an ultimate goal of reducing data tape production by 60 days (data age 4-6 months) and proportionate reductions in the intermediate goals for field printouts and preliminary data printouts. The committee does not feel that production of both field printouts and preliminary data printouts are essential. If an alternative reporting scheme would result in a significant time reduction, then CAL should recommend these measures to the Executive Committee in May 1986. Some examples of current practices which we feel might be examined at are 30-day batching, holding data for long times before keypunching, priority of manpower to data review vis-a-vis other activities for which they are responsible, and automation of laboratory data acquisition.

4. In light of the above comments/recommendations the committee notes that all data flows through every check step in the system. Once much of the data passes the early check steps it is not impacted by later check steps (i.e., once status is "defined", it does not change). The committee recommends that ways be explored for splitting out the "defined status" data and passing it to the Coordinator's Office at an earlier time. Only those data for which questions remain would go through all data steps until defined. Our feeling is that this will

reduce data handling in later steps and possibly speed data production. New programs and data controls would have to be implemented at both the Coordinator's Office and CAL to accommodate this. Both activities should be prepared to recommend a coordinated approach to implement this recommendation by April 1987.

As its final action the committee reviewed the April 1984 committee's report to ascertain the status of every recommendation in that report. In addition to those already commented on the following unresolved issues remain:

1. A redesigned "new" field form be entirely key punched at CAL and data now passed to CSU via the "old" hardcopy field form be transmitted via data tape.
   This committee is not sure that this is still a good solution. The committee recommends that CAL and the Coordinator's Office present their recommendations for how this transfer should be effected to the Executive Committee, in May 1986. Any such approaches must address sample cost and how the increased load at CAL would be paid for.

2. The Coordinators Office should resolve its notes codes to uniquely identify a single protocol transgression.
   We recommend that the Coordinators Office present a solution to the problem of the SP note code which was identified as having several meanings. This presentation should be made to subcommittee #3 prior to the May 1986 Executive Committee meeting.

3. An outside professional, systems audit of the CAL-Coordinators Officers should be undertaken.

   We recommend that the Coordinators Office explore ways this can be done and present progress reports at each Executive Committee meeting until it's done.

SECTION 7
The NADP/NTN Site Visitation Program

Section 7 is a reproduction of a work plan prepared previously and submitted to EPA in 1985. The page numbers (34-74) have been changed to conform with the pagination scheme of the present report.

THE NADP/NTN SITE VISITATION PROGRAM

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SECTION 1
INTRODUCTION

This document is the work plan which describes the protocol and procedures for quality assurance assistance to be provided to the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) precipitation collection sites during survey visits over the period 1984-1987.

The NADP/NTN consists of approximatey 200 monitoring stations strategically located across the contiguous United States. Each of the 200 collection sites is to be visited once in the three year period. To accomplish this, about 65 sites are to be visited each year by personnel of the Research Triangle Institute (RTI) under contract to the U.S. Environmental Protection Agency. The goals for quality assurance assistance to the NADP/NTN collection sites are to:

(1) Provide a qualitative assessment of each site and its surroundings, the operator's adherence to sample collection and analysis procedures, and the condition of the site's collection and analysis equipment through an on-site systems survey;

(2) Provide a quantitative assessment of the accuracy of response of measurement devices for precipitation depth, mass, temperature, conductivity, and pH through an on-site performance survey;

(3) Provide technical assistance to the operator by verbal explanation, minor troubleshooting, repair, and calibration of equipment, and recommendations for sources of corrective action;

(4) Submit reports to the NADP/NTN Quality Assurance Manager and the EPA Project Officer detailing quality assurance results and technical assistance provided.

(5) Document the sites and their surroundings by assembling a collection of site maps and color photographs.

This work plan is divided into five sections and one Appendix. The topics discussed are as follows:

Section	Topic
1	Introduction
2	Preliminary Planning
3	Protocol and Procedures for Collection Site Visits
	- Scheduling
	- Pre-trip Preparations
	- Site Survey Visits
4	Reports
5	References
Appendix A	NADP/NTN Systems and Performance Survey Questionnaire

SECTION 2
Preliminary Planning

Prior to on-site visits to the NADP/NTN collection sites, a period of training and familiarization for site visitors is to take place in order to develop a work plan which incorporates: the latest technical and administrative information about the NADP/NTN; comments and suggestions from the NADP/NTN's sponsoring agencies and contracted offices and laboratories concerning the site visits; protocol and procedures for initiation and conduct of the site visits.

The steps taken to accomplish this -- document review, consultation, training, review of site information, and preparation of the work plan -- are discussed below. Figure 1 shows the schedule for providing quality assurance services to the NADP/NTN.

DOCUMENT REVIEW

All pertinent documents will be reviewed including, but not limited to: the document for the design of the National Trends Network (1, 2); the NADP Quality Assurance Plan, 1984 (3); the NADP Instruction Manual for Site Operators (4); Volume V of the Quality Assurance Handbook for Air Pollution Measurement Systems - Manual for Precipitation Measurement Systems (5); the NADP/NTN site selection and installation manual (6); the NTN Site Visitation Checklist (7); and operation manuals for field measurements equipment (8,9).

CONSULTATION

RTI will consult with the following NADP/NTN sponsors and contractors to gather technical and administrative information, assess the quality assurance needs of the NADP/NTN, and plan the protocols and procedures for site visitations and reporting and archiving the data gathered.

- The Natural Resources Ecology Laboratory of Colorado State University (contractor for overall coordination of the NADP/NTN sampling and analysis program).

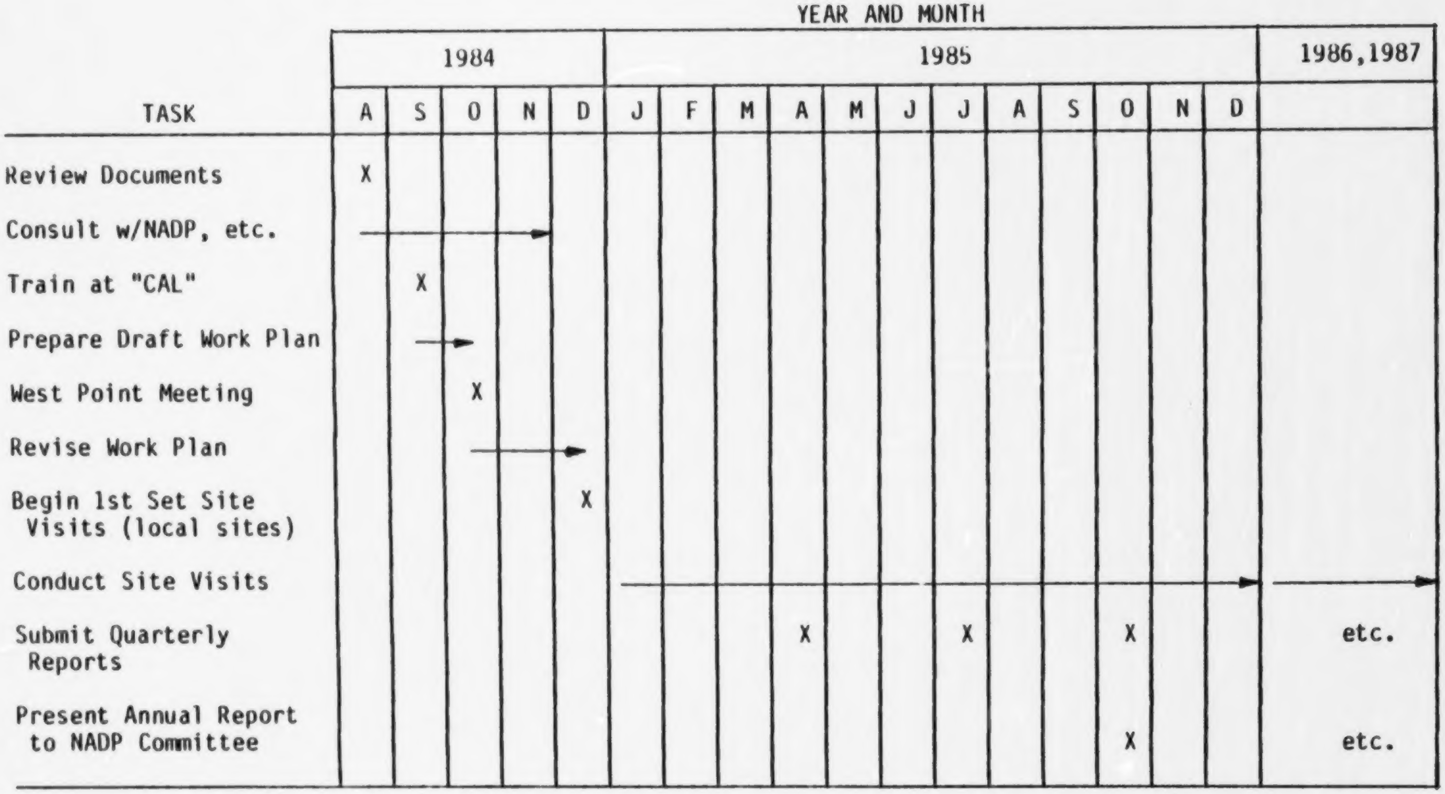


FIGURE 1. SCHEDULE OF QUALITY ASSURANCE SERVICES TO NADP/NTN

- Public and private sponsors of sites in the NADP/NTN (U.S. Geological Survey, National Oceanic and Atmospheric Administration, National Parks Service, among others).
- Illinois State Water Survey (contractor for laboratory measurements, data processing, site interaction, and training through the Central Analytical Laboratory, CAL).
- Science Research Laboratory of the United States Military Academy (contractor for network design and selection of sites for the NADP/NTN).
- U.S. Environmental Protection Agency (sponsoring agency for the on-site quality assurance visits).

TRAINING SESSIONS

Attend NADP/NTN Site Operators Instructional Course

Two RTI personnel will attend the first available instructional course for NADP site operators. This is to be at the CAL in Champaign, IL, September 11-13, 1984. Information on quality control results from existing sites will be obtained; the CAL field site will be visited.

Participate in Planning Meeting

Three RTI personnel will attend a meeting October 11 and 12, 1984 at the United States Military Academy, West Point, New York. At this meeting further instructions and information concerning the NADP/NTN sites and desired quality assurance activities will be obtained, the NADP/NTN site visitation checklist created and used by Majors Robertson and Graham during their visits will be reviewed, and procedures for site systems and performance audits will be observed during visits to the Biscuit Brook and West Point NADP/NTN monitoring sites.

WORK PLAN

Preliminary and final work plans are to be prepared. Each will include protocols for site visits, reporting of information, and a questionnaire for data entry. The plan will address quality assurance needs of the NADP/NTN established through document review, consultation, and training sessions.

SECTION 3
Protocols and Procedures for Collection Site Visits

SCHEDULING

Each NADP/NTN site is to be visited once in a three year period. It is anticipated that one-third of the sites will be visited each year during the period 1985-1987. Prior to the scheduling of site visits, RTI will consult with the NADP/NTN quality assurance manager and CAL personnel to determine which sites, if any, should be seen on a priority basis. Visits are to be made in an efficient, cost-effective manner by planning trips to several sites in the same vicinity.

The following sequence is to be followed when arranging a visit to a collection site.

- At least two months before the anticipated date of visit, RTI will select a set of sites in a location suitable for a trip lasting up to two weeks and set a tentative schedule for visits. As many as eight sites may be visited in this time frame, depending on the proximity of the sites.
- The NADP/NTN Quality Assurance Manager, the Central Analytical Laboratory (CAL) of the Illinois State Water Survey, and the sponsoring agency will be notified by letter of the proposed visits. CAL is to supply pertinent information to RTI concerning each site.
- Each site's supervisor will be telephoned to set up the visit. Depending on the wishes of the site supervisor, the supervisor will contact the operator or RTI will contact the operator to confirm the date, time, and place of the visit. If the supervisor makes the arrangement, he is to contact RTI at least two weeks prior to the planned visit to confirm or alter the initial plan.
- A form letter will be sent to each site's supervisor and operator which confirms the date, time, and place of the visit. This letter is to also give a brief agenda for the visit and an estimate of the time to set aside for the visit (4 to 5 hours).

The general schedule of activities for the quality assurance training activities and site visits is given in Figure 1. A flow chart of the activities carried out in preparation for, conduct of, and reporting of a site visit is given in Figure 2.

PRE-TRIP PREPARATION

Prior to each trip to a set of collection sites, the following preparations will be made: travel arrangements; preparation of quality assurance test equipment and materials; review of site-specific quality control information; packaging and check of all equipment and supplies; preparation of site survey notebooks. Several of these items are discussed in more detail in the performance survey subsection.

Review of Site-Specific Quality Control Information

Information on individual collection sites is to be supplied to RTI by the NADP/NTN Manager's Office and CAL in advance of the audit trips so that site contacts can be established and special attention can be given to an individual site's needs.

This information, supplied in the form of a computer printout provided by the QA Manager, is to contain the following information for each site.

- Site supervisor's and operator's name, address, and telephone number
- Description of site and surroundings
- List of equipment at site
- Confidential information on operator's performance
- The site description questionnaire

This information is to be reviewed at RTI prior to visiting the collection site. Information of a confidential nature will not be discussed with the site operator.

Preparation of Site Survey Notebooks

Notebooks will be prepared for use at each site. Each notebook will contain information concerning the site (operator, location, etc.), a record of pre-trip confirmation of test solutions, balance weights, etc., and the site survey questionnaire. Each notebook will

FLOWCHART FOR SITE VISITS

I. SELECT SITE FOR VISIT AND INITIAL COMMUNICATIONS

- Advise QA Manager, CAL, site sponsor of plans; request site information; receive go-ahead
- Contact site supervisor; site operator
- Send letter of confirmation to supervisor, operator
- Advise EPA that trip plans are complete

II. PRE-TRIP PREPARATION

- Make Travel Arrangements (air, car, hotel)
- Prepare and Test Quality Assurance Materials
- Review Site-Specific Quality Control Information (maps, QC test results, etc.)
- Check Equipment and Supplies
- Prepare Site Visit Notebooks

III. CONDUCT SITE VISIT

- Outline Activities to Supervisor and Operator
- Assess Site and Surroundings (map, photographs, obstructions, sources)
- QA Tests of Precipitation Collector and Gauge
- Adjust or Calibrate Collection Equipment as Required
- Assess Operator Handling and Transport of Collection Bucket
- QA Tests of Conductivity and pH Meters, Temperature, Mass
- Examination of Site Records, Rain Gauge Charts
- Answer Questions; Provide Instruction
- Prepare Short Report; Conduct Exit Interview

IV. REPORTING

- Short Report Prepared; Left with Supervisor or Operator
- Copy of Short Report Forwarded to NADP/NTN QA Manager and to CAL
- Copy of Site Visit Notebook Sent to NADP/NTN, QA Manager; File Original
- Summary Reports Prepared Quarterly
- Annual Report Presented to NADP/NTN Committee

FIGURE 2. FLOWCHART FOR SITE VISITS

be bound, numbered, and checked for accuracy before and after the site visit. The original notebook will be filed at RTI using a document control system. One copy of the notebook will be provided to the NADP/NTN QA Manager.

SITE SURVEY VISITS

RTI personnel will accompany the supervisor and operator to each collection site and field laboratory with the dual aims of (1) documenting the site, its operation, and the accuracy of its instrument response to various quality assurance tests and (2) providing information, training, and instruction for operators and supervisors, equipment calibration and minor maintenance as needed, and establishing contacts for further information and/or major repairs. A general list of items to be checked is given in Table 1. Variation from protocol or performance specifications for these items may affect data quality.

The initial set of visits will be to three sites in North Carolina. For these visits RTI will send a team of three people so that each person's approach to the survey can be evaluated and shared immediately. The goals of this team approach are to obtain additional hands-on experience and to standardize the visit as much as is practicable so that the same procedures are used when additional sites are later visited by an individual.

Systems Survey

A quality assurance systems survey will be conducted at each site to qualitatively assess the site, its surroundings, and the operator's adherence to procedures specified in the NTN design document (2) and in the NADP/NTN site operator's instruction manual (4). The operator will demonstrate sample collection and analysis procedures which will be observed with special attention given to calibration procedures and sample handling technique. Site equipment will be examined for signs of wear or faulty operation. It will be noted whether solutions and equipment are properly stored. Site logbooks and rain gauge charts will be examined for legibility, completeness, and accuracy.

For those sites powered by solar panels, the rating of the system (in amps/week) will be determined or approximated. An assessment of the adequacy of the solar panels for year-round use will be made.

TABLE 1. LIST OF ITEMS TO BE CHECKED DURING SITE SURVEY VISIT

Precipitation Sampler

- lid/bucket seal
- absence of gaps
- sensor heater works
- clutch tension
- clutch wear
- winter problems
- proper counterbalance
- contamination by straps
- snow roof design, material, orientation
- level
- lid tension or drop
- bucket/sample handling
- orientation, height
- distance from other equipment

Supplies

- check inventory
- shortage of buckets
- excess buckets

Mass

- accuracy of response
- calibration weight handling
- tolerance checks
- correct use of balance

Precipitation Gauge

- winterization
- calibration of weight response
- cleanliness
- time calibration
- event marker working
- accuracy of chart reading
- Belfort gauge reported
- distance from other equipment
- height

pH Meter and Use

- accuracy of response
- no electrodes in bucket
- ±0.2 pH unit agreement with test solution
- electrode condition
- electrode brand
- order of use
- use of pH check solution
- storage of buffers, check solutions

Conductivity

- accuracy of response
- no electrode in bucket
- use of 75 μmho/cm standard

Information from the systems survey will be entered in the systems survey questionnaire (Refer to Appendix A of this work plan). Photographs (color prints) of the site will be taken. The directions N, E, S, and W will be photographed as viewed from the precipitation collector. Additional views will be taken as specified in the questionnaire.

Performance Survey

A quantitative performance survey is to be conducted at each site. Table 2 lists the equipment that will be checked for performance and the type of test to be used. Criteria for evaluating performance are specified in the NADP Quality Assurance Plan (3). All information will be recorded in the performance survey questionnaire (refer to Appendix A). Several items having to do with quality assurance test equipment, materials, and procedures are discussed below.

Precipitation Depth. The calibration of the Belfort recording rain gauge will be checked over the range 0 to 12 inches by use of the certified weight set (Number 8849 6P-1) obained from Belfort Instrument Company. The certification of the weight set will be checked by periodically reweighing the weights. The operator is to remove the chart from the gauge and replace it with a new one. Proper alignment of the chart on the drum is to be verified by the operator and the site visitor. Next, the zero reading is established and then a series of weights are placed on the gauge to simulate precipitation in one inch increments from 1 to 12 inches (in very dry areas only the range 0 to 6 inches may be checked). Gauge response is recorded in the notebook and on the chart.

If any one reading is greater than 0.10 inch from the designated value, the gauge is to be calibrated (weather permitting) using the procedure given in the gauge manual (8). Completion of a successful check or calibration will be recorded in the notebook.

At least one agency (NOAA) has its own program of precipitation gauge calibrations. If any NOAA-owned gauges are found to be outside the tolerance (0.10 inch), the site supervisor will be notified; no calibration is to be performed by the site visitation team.

TABLE 2. NADP/NTN SITE MEASUREMENTS AND PERFORMANCE SURVEY METHODS

Site Measurement	Measurement Device	Performance Survey Method
Rain Depth	Rain Gauge (Belfort)	Challenge with known weights
Precipitation Sample Collection	Precipitation Collector (Aerochem Metrics)	Measured resistance across sensor, measure tension and drop of bucket lid, measure temperature and voltage of activated sensor.
Mass	Triple Beam Balance	Challenge with traceable weights
pH	pH Meter and Electrode	Challenge with simulated precipitation sample of known pH
Conductivity	Conductivity Meter and Cell	Challenge with simulated precipitation sample of known conductivity

Precipitation Collector. Several aspects of the Aerochem Metrics precipitation collector are to be checked. Mechanical. The proper opening and closing cycle is checked by applying deionized water to the sensor and watching and timing the open-close cycle. Wear on thrust collar indent and thrust tooth is visually checked. Clutch pressure is checked by the mechanism's ability to life 1640 g (two Belfort weights). Tension on lid. This is to be checked in two ways: lifting the lid slightly through a spring scale and noting the tension required; measuring the distance between the collector table top and the bottom edge of the lid with and without the collection bucket in place. Sensor. The sensor's cleanliness, proper voltages, electrical resistance at which the lid displaces, and heating (measured by a thermocouple placed against the sensor plate) are checked.

Mass. The accuracy of mass determination of the collection bucket contents is to be checked by having the operator weigh several Belfort rain gauge weights which have been calibrated to ±0.1 grams against IOLM-certified brass weights.

pH and Conductivity. The accuracy of pH and conductivity measurements is to be checked by having the site operator analyze a simulated precipitation sample. This sample will be a dilute solution of one of the EPA/NBS simulated precipitation reference materials which have been in use as quality assurance materials for several years (10). The concentrated solution is to be diluted and a portion checked in the laboratory before being taken to a collection site. The solution is to be rechecked upon its return from a field trip. As a precaution against contamination or spillage of the test solution, an undiluted sample will be taken and diluted on site if necessary.

The simulated precipitation test sample will be given to the operator as a 20 mL aliquot. The test sample will not be placed in a collection bucket.

To troubleshoot the pH meter, a pH meter tester will be employed.

Technical Assistance

Technical assistance in the form of instruction, explanation, or demonstration as needed to improve site performance is to be provided.

This assistance might include a discussion or demonstration of proper analytical techniques, instrument use, and calibration procedures. Operator questions will be answered or referred to the proper program personnel.

In the event there is an equipment deficiency at the site, the problem will be identified, corrective action recommended (see maintenance subsection) and, as necessary, the operator and supervisor will be referred to CAL for additional information and guidance.

Maintenance

Minor maintenance will be performed at NADP/NTN sites in an effort to improve site performance. The level of maintenance provided is limited by the amount of time required to complete a particular task and the amount of equipment which can be transported to the field.

For the purpose of this work plan, maintenance is divided into three categories: (1) calibration, (2) troubleshooting, and (3) repair. In general, the site visitor will calibrate any site instrument which is out of tolerance and will attempt to identify the source of malfunction in faulty equipment. Repair will be performed but only where replacement of minor parts or adjustment is required. Table 3 lists typical problems requiring maintenance and the level of effort to be provided in each case.

Exit Interview

At the conclusion of the site survey, a short report of the visit will be written and the results will be discussed with the site operator and/or supervisor. During the exit interview the operator and supervisor will have time to ask additional questions and express their feelings about the NADP/NTN program and their responsibilities within it.

TABLE 3. LEVEL OF EFFORT FOR MAINTENANCE

	Calibrate	Troubleshoot	Clean	Adjust	Replace
Aerochem Metrics Collector					
Worn Thrust Collar	N/A(a)	Yes	No	Yes	No
Faulty Sensor	N/A	Yes	Yes	No	No
Poor Bucket Lid Seal	N/A	Yes	N/A	Yes	Yes(b)
Lid Liner	N/A	N/A	No	N/A	No
Faulty Motor Box	N/A	Yes	N/A	N/A	No
Improper Counter Weight	N/A	Yes	N/A	Yes	Yes(c)
Improperly Mounted Snow Roof	N/A	N/A	N/A	Yes	No
Fuses	N/A	Yes	N/A	N/A	Yes
Belfort Rain Gauge					
Faulty Clock	No	Yes	No	No	Yes
Out of Tolerance Gauge	Yes	Yes	Yes	Yes	No
Pen and Event Marker Hang-up	N/A	Yes	Yes	Yes	Yes
Low Oil in Damper	N/A	Yes	No	N/A	Yes
Pen Traverse Off Time Line	N/A	Yes	Yes	Yes	No
Improper Zero Adjust	N/A	Yes	Yes	Yes	No
No Event Marks	N/A	Yes	Yes	N/A	No
Field Laboratory					
Poor pH Measurement	Yes	Yes	Yes	Yes	No
Poor Conductivity Measurement	Yes	Yes	Yes	Yes	No
Poor Mass Measurement	Yes	Yes	Yes	Yes	No

(a) N/A = not applicable

(b) Will replace spring.

(c) Will replace part if it is on hand at site.

SECTION 4
REPORTS

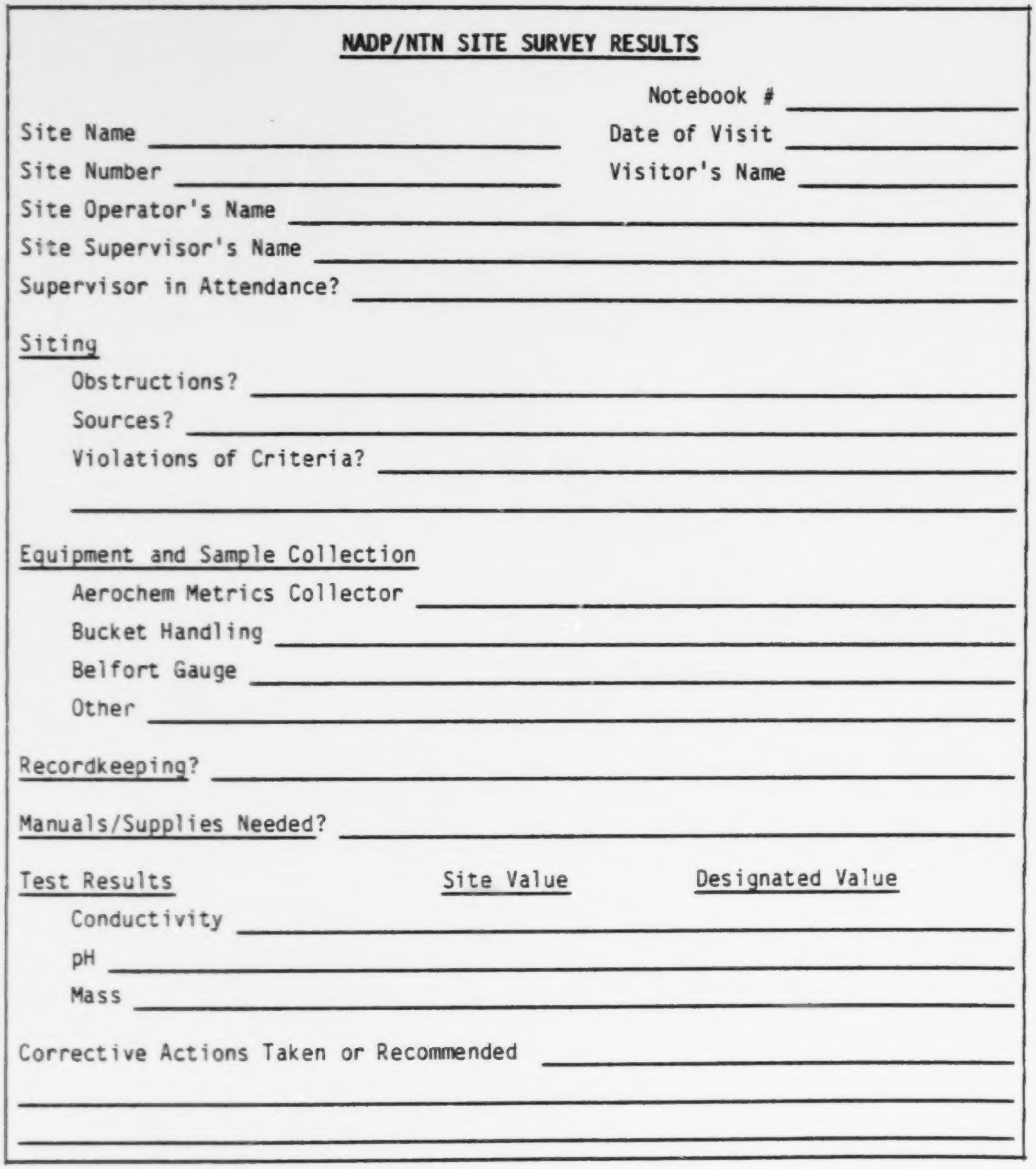
During and at the conclusion of each collection site visit, the visitor will verbally brief the supervisor and operator on the results of the systems and performance survey and present a copy of a short report. The purpose of this exit interview is to convey information only and is not to offer any type of judgement or criticism of the site.

Copies of this brief report of the results and recommendations for corrective action are to be mailed to the CAL and to the NADP/NTN QA Manager. These reports are to be on NCR-type paper so that a number of copies are produced. Figure 3 illustrates the contents of the brief report.

Bound copies of the original notebooks containing the site survey results will be kept on file at RTI. Copies of the notebooks, the photographs, and annotated maps will be sent to the QA Manager's office for study and archiving.

Draft reports summarizing the information from site surveys will be provided on a quarterly basis and will be distributed to the NADP/NTN QA Manager and the EPA Project Officer who will review them for clarity and technical accuracy and request the final report. The final report is to be submitted to and distributed from the QA Manager's office. The quarterly report will consist mainly of tabulated summaries of site survey results and recommendations for corrective action as warranted.

The annual report is to consist of a technical summary of the year's activities and will be presented annually in a briefing to Task Group D, the NADP Technical Committee, and/or the agency sponsors. The format of this report is to be set by consultation with the QA Manager.



NADP/NTN SITE SURVEY RESULTS

Notebook # ____________

Site Name ____________ Date of Visit ____________

Site Number ____________ Visitor's Name ____________

Site Operator's Name ____________

Site Supervisor's Name ____________

Supervisor in Attendance? ____________

Siting

Obstructions? ____________

Sources? ____________

Violations of Criteria? ____________

____

Equipment and Sample Collection

Aerochem Metrics Collector ____________

Bucket Handling ____________

Belfort Gauge ____________

Other ____________

Recordkeeping? ____________

Manuals/Supplies Needed? ____________

Test Results	Site Value	Designated Value
Conductivity		
pH		
Mass		

Corrective Actions Taken or Recommended ____________

____

____

FIGURE 3. FORM FOR BRIEF REPORT OF SITE VISIT

SECTION 5

REFERENCES

1. Pickering, R. J. and W. L. Bradford. "Atmospheric Deposition Monitoring Under the National Acid Precipitation Assessment Plan," in Proceedings of A Specialty Conference on Atmospheric Deposition, Air Pollution Control Association Publication SP-49. (1982)

2. Robertson, J. K. and J. W. Wilson. "Design of the National Trends Network for Monitoring the Chemistry of Atmospheric Precipitation," U.S. Geological Survey Circular 964. (1985)

3. "The NADP Quality Assurance Plan," NADP Quality Assurance Steering Committee. (1984)

4. Bigelow, D. S. "NADP Instruction Manual - Site Operation," National Atmospheric Deposition Program, Ft. Collins, CO. (January 1982)

5. "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume V - Manual for Precipitation Measurement Systems," U.S. Environmental Protection Agency Publication No. EPA/4-82-042a & b. (March 1983)

6. Bigelow, D. S. "NADP/NTN Site Selection and Installation. NADP Instruction Manual," National Atmospheric Deposition Program, Ft. Collins, CO. (July 1984)

7. "NTN Site Visitation Checklist". Prepared by Major J. K. Robertson, U.S. Military Academy, West Point, N.Y. (1982)

8. "Instruction Book for Universal Recording Rain Gauge (Cat. No. 5-780 Series)," Book No. 8777, Belfort Instrument Company, Baltimore, MD. (September 1976)

9. Dossett, S. "Aerochem Metrics Precipitation Collector Maintenance Manual," SWS Contract Report 348, Illinois State Water Survey, Champaign, IL. (September 1984)

10. Koch, W. F., G. Marinenko, and J. W. Stolz. "Simulated Precipitation Reference Materials, IV," National Bureau of Standards Publication Number NBSIR 82-2581, Washington, DC. (October 1982)

SYSTEMS AND PERFORMANCE SURVEY QUESTIONNAIRE: FIELD

Site Characteristics

Identification.

101 Site name ______________________ ID # ________

102 Site supervisor ______________________

103 Site operator ______________________

104 Other site operators ______________________

105 Telephone ______________________

106 Mailing address ______________________
____

107 Shipping address ______________________
____

108 Date of site audit visit ______________

109 Time of site audit visit ______________

Weather condition during time of site visit

110 Sky (circle one) clear overcast cloudy ______

111 Wind (circle one) calm gusty sustained wind ______

112 Precipitation (circle one) none fog mist rain
sleet snow ______

113 RTI auditor's signature ______________________

114 Is this an NADP site? __________ An NTN site? __________

115 Has site operator or supervisor attended CAL course? ______

116 How long has operator been site operator? ______________

Logistics.

		Yes	No
	Is the site accessible		
117	in summer?	___	___
118	in winter?	___	___

119 How far from the nearest road is the precipitation collector? __________ (m)

120 Type of road surface? ______________

121 How close to the collector does the operator park his vehicle? __________ (m)

Topography and Land Use.

Explain all yes answers in comments at the end of this section and draw brief sketch of site.

Within 30-m

		Yes	No
122	Is the slope greater than 15 degrees?	___	___
123	Is the ground cover other than natural vegetation and/or more than 2 feet high?	___	___
124	Are there plowed fields or tilled areas?	___	___
125	Is there equipment present other than the specified rain gauge and collector?	___	___
126	Are there grazing animals?	___	___
127	Are there any objects (solar panel, rain gauge, etc.) close to the collector or rain gauge which might deflect the wind? Describe on sketch.	___	___

Within 100-m

		Yes	No
128	Are there any objects (trees, overhead wires, etc.) which project on the collector or rain gauge with an angle greater than 45° from horizontal?	___	___
129	Are there storage facilities for chemicals, vehicles, etc.?	___	___
130	Are there sources of frequent ground, water, or air traffic?	___	___

Within 500-m to 50-km (i.e., within 30 miles)

		Yes	No
131	Are there large concentrations of animals such as feedlots, dairy barns, kennels, etc. within 500-m? (1600 feet)	___	___

		Yes	No
132	Are there industrial operations such as factories, chemical plants, sewage treatment plants, etc. within 10-km? (6 miles)	___	___
133	Are there up-wind industrial operations within 20-km? (12 miles)	___	___
134	Are there suburban or urban areas containing more than 10,000 people within 10-km? (6 miles)	___	___
135	Are there upwind suburban or urban areas containing more than 10,000 people within 20-km? (12 miles)	___	___
136	Are there cities containing more than 75,000 people within 20-km? (12 miles)	___	___
137	Are there upwind cities within 40-km? (25 miles)	___	___

Comments:

Sketch of NADP/NTN Field Site

N

W E

S

Site Name ____________________ Site Number ________________________

Date of Visit ________________ Name of Surveyor ____________________

Scale ________________________

Draw additional sketches on back of preceeding pages.

Aerochem Metrics Sampler

Yes No

System Check.

201 Model # ______________ ID # ____________

202 What type of power does collector have? (circle)

(a) AC only
(b) AC with aerochem trickle changer/battery
(c) battery only
(d) battery with external AC powered charger
(e) Solar
(f) Other ________

If Solar Power, Enter 203 thru 206:

203 Manf. ________________________ Model _________

204 Number panels __________ Area of each _________

205 Panels facing __________ Angle from horz. _____

206 List any objects that may shade panels during hours of 8 am to 4 pm. ____________________________________

207 Is there evidence of battery electrolite spillage? ___ ___

208 Has collector failed to operate during last year because of a power failure? ___ ___

209 Is the collector on a platform? ___ ___

210 How high is platform? ____ in.

211 Is the height above ground standard ___ ___

212 Is collector level? ___ ___

213 Is collector stable? ___ ___

214 Is the collector standard, base not enclosed? ___ ___

215 What is the collector orientation (wet bucket is to N S E W)? ________

216 Is the precipitation sensor old or new type? ________

217 Is screw head of sensor orientated away from dry bucket? ___ ___

218 Is sensor clean? ___ ___

		Yes	No
219	Is sensor gap between baseplate and grid constant?	___	___
220	What is the sensor gap distance? ________ in. ________ mm		
221	Are buckets installed properly?	___	___
222	Are buckets held with tie down strap (springs)?	___	___
223	Is the lid in correct wet/dry position?	___	___
Does The Collector Have			
224	Aluminum snow roof?	___	___
225	Polycarbonate snow roof?	___	___
226	Polycarbonate lid cover?	___	___
227	Heated lid pad	___	___
228	Other ________________	__________	
229	Snow roof orientated properly?	___	___
230	How many counter weights does collector have?	__________	
231	What are their sizes? 2 x ______ 2 x ______ 2 x ______ 2 x ______		
232	Are counter weights correct for type lid?	___	___
233	What is the clutch type, 1" or 1.5"?	__________	
234	Is the clutch face worn?	___	___
235	Are the alignment of bars ok?	___	___
236	What is the collector distance from rain gauge? ________ ft ________ m		
237	Is the collector bucket rim within ±0.3 M (12 inches) of the same height as the top of the Belfort gauge?	___	___
238	Is collector connected to rain gauge event marker?	___	___

Performance Check.

239	Measure temperature of sensor at 1/3 from top.	________ °C	
240	Measure output voltage to rain gauge while closed.	______ V	
241	Tenson to lift lid slightly with spring scale.	________ g	
242	Measure distance of lid from base with bucket in	________ mm	
243	Does the lid seat properly on wet bucket?	___	___

Yes No

Add several drops of water to sensor plot near top of sensor grid.

244 How long (seconds) does it take for the bucket cover to move from wet to dry bucket. _____ sec

245 Does sampler open smoothly and come to rest on dry bucket? ___ ___

246 Does it stay there on dry bucket? ___ ___

247 Does the lid seat properly on dry bucket? ___ ___

Observe condition of underside of bucket cover. Does it have:

248 Split polyethylene or degraded polyurethane ___ ___

249 Dirt or mildew? ___ ___

250 Measure output voltage to rain gauge while open. ________V

251 What is the maximum sensor temp. observed after 5 to 10 min. _________ min _________ °C

Remove Wet Bucket

252 Blow off water. Does bucket cover return to wet side? ___ ___

253 Measure distance of lid from base with wet bucket removed. ______ mm

254 Difference of (241) ______ mm - (252) ______ mm = ______ mm

IF Diff < 3 mm (1/8") determine why?

255 How many Belfort gauge test weights will bucket cover lift when sensor is activated? (3 max.) _________

256 Is clutch OK? ___ ___

257 Test sensor with series of resistors until one opens the bucket. Open value. ______ k

258 Does sensor: _________

A. Heat continuous

B. Not heat

C. Operate properly

Quiz operator about collector's past operation. Take this information down, along with your observations and:

(1) Make necessary simple adjustments or repairs. Explain below what you did. Verify operation by retesting.

(2) Make recommendations for more extensive repair. Explain below.

(3) Guide operator through S. Dossett's troubleshooting manual if there are questions.

Operator or Site Visitor Comments.

Belfort Rain Gauge

301 Model # ______________ S/N __________________

System Check.

		Yes	No
302	Is the gauge level?	___	___
303	Is the gauge stable?	___	___
304	Is the collection bucket level?	___	___
305	Is the opening round?	___	___
306	Is gauge top approximately 1.5 m (59") ± 0.5 m (20") above ground?	___	___
307	If gauge is on a platform, describe the size, height of platform.	______	
308	What is rain gauge distance from sampler? _____ft	_____m	
309	Is the access door of the rain gauge on the down wind side of the predominant wind path?	___	___
310	Does the rain gauge have an alter shield?	___	___
311	If rain gauge is inoperative, how does operator obtain daily/weekly precipitation information? ____		
312	Is there a back-up rain gauge within a half mile (805 m)? distance _______ direction _______	___	___
313	Does site have NADP sand bottle weights?	___	___
314	Is the rain gauge calibration checked twice per year?	___	___
315	In winter, is the funnel removed and is an antifreeze and/or oil mixture put in bucket?	___	___
316	Except during winter when antifreeze is present, is catch bucket emptied every Tuesday?	___	___
317	Is the catch bucket corroded or dirty?	___	___
318	Is excessive dust present inside the gauge?	___	___

		Yes	No
319	Is the pen recording a clear trace?	___	___
320	Is the pen offset one day on the chart as recommended by NADP?	___	___
321	Is the gauge pen (not even pen) set to correct time?	___	___
322	Is the pen located at the correct hour of the day, expressed as local time, within ± 1 hour? Give hour ______________.	___	___
323	Are event marks made when the sampler opens and closes?	___	___
324	How many hours difference are there between the event marker and the correct time?	__________	
325	Is the clock ticking?	___	___
326	Is clock battery operated?	___	___
327	Dampening fluid level approximately 0.25 in from top?	___	___
328	Are zero adjustments made using both coarse and fine knobs?	___	___
329	Does the pen traverse the chart time line within ± 1 hour?	___	___
330	Is gauge in cal (error < .1").	___	___
331	Point where error is .1" or greater.	__________	
332	Gauge calibrated by RTI.	___	___

Calibration Check.

Have the site operator remove the top cover of the gauge, exposing the collection bucket. Jiggle the bucket to cause a deflection of the pen and enter initials, date, and "removed for audit" on the chart. Store chart. Have operator remove the recorder drum and install a new chart. Label the new chart with the site name, date, and time and the auditor's initials. Remove the collection bucket, install the weight support device, and zero the pen on the chart.

(1) Proceed to test the response of the rain gauge to various test weights as follows.

  a. Rotate the drum by hand for approximately 0.25 inch and mark the chart reading as "baseline."

  b. Carefully place calibrated weights, each equivalent to 1 inch rain, on the weight support and rotate the drum after each weight. Use a total of 12 weights.

  c. If the response at any loading differs by more than 0.1 inch from expected value, calibrate the gauge.

(2) Zero the pen on the chart repeat (1).

Remove the audit chart and have station operator replace the original chart on the drum and set the pen to the correct day and hour. Transfer results from gauge chart to Table A-1.

Enter Comments her and/or on Table A-1. ______________________

____

____

____

____

____

TABLE A-1. RESULTS FOR BELFORT RAIN GAUGE CHECK

Site # ____________________ Site Name ____________________
301 Belfort Gauge Model # ____________ S/N ____________________
Date of Visit ____________________
333 Gauge Calibrated by RTI Yes ___ No ___

NO ADJUSTMENT

Sum of Audit Weights, Inches	Gauge Chart Reading, Inches	Difference Inches
baseline		
1.0		
2.0		
3.0		
4.0		
5.0		
6.0		
7.0		
8.0		
9.0		
10.0		
11.0		
12.0		

PEN SET TO CHART ZERO

Sum of Audit Weights, Inches	Gauge Chart Reading, Inches Before Calib.	Difference Inches
baseline		
1.0		
2.0		
3.0		
4.0		
5.0		
6.0		
7.0		
8.0		
9.0		
10.0		
11.0		
12.0		

Sample Collection Procedures

Sample Handling.

		Yes	No
401	Does operator approach sampler from downwind direction?	___	___
402	Is the sample bucket changed if, after seven days, no precipitation has occurred?	___	___
403	Does the operator check the collector weekly, noting lid movement check on Belfort chart?	___	___

Have operator describe procedure followed during a bucket change. Answer the following questions.

		Yes	No
404	Is bucket checked for contamination before removal?	___	___
405	Is bucket or top held only on outside surface?	___	___
406	Is open bucket ever placed on the ground?	___	___
407	Is lid placed on bucket before removal?	___	___
408	Is bucket top securely attached before transporting sample to home laboratory?	___	___
409	Is bucket placed in plastic bag and then in shipping box before transport to the field laboratory?	___	___

Comments ____

____

____

____

Systems Check of Field Laboratory

		Yes	No
501	Is there adequate space for operation?	___	___
502	Is the space around the balance, pH and conductivity meters clean and free from dust, paint flakes, household chemicals?	___	___
503	Is the laboratory temperature controlled between 18 (64.4°F) and 25°C (77.0°F)?	___	___
504	Are the samples kept from direct sunlight during analysis?	___	___
505	Is equipment secure and protected from tampering?	___	___
Are the following manuals and leaflets available?			
506	Sample Collector Manual	___	___
507	Belfort Rain Gauge Manual	___	___
508	pH Meter Manual	___	___
509	pH Electrode Leaflet	___	___
510	Conductivity Cell Leaflet	___	___
511	Balance Manual	___	___
512	Field Operator's Manual - NADP	___	___
513	Letter Updates to Field Operator's Manual	___	___
514	Battery Charger Instructions (if used)	___	___
Are the following items present at the field laboratory?			
515	pH meter with electrode	___	___
516	Conductivity meter and cell	___	___
517	Balance	___	___
518	Wash bottle	___	___
519	Test tubes, polypropylene	___	___
520	How many clean buckets with mailing boxes on hand?	_______	
521	Does operator rotate these? (first in, first out)	___	___

		Yes	No
	Are the following reagents and test solutions present and properly stored?		
522	Distilled or deionized water	___	___
523	Standard KCl solution, 75 μmho/cm	___	___
	Note preparation date	______	
524	pH 4.01 buffer solution	___	___
525	pH 7.00 buffer solution	___	___
526	Are pH buffers stored at room temperature?	___	___
527	pH electrode test solution	___	___
	Note preparation date	______	
528	Is the pH electrode test solution stored at room temperature?	___	___
529	pH electrode filling solution	___	___
530	Has operator incorporated any item into his laboratory procedure not specified in the NADP Operator's Manual? If yes, describe. ______________ ______________________________	___	___
531	Does operator weigh sample, lid, and contents before removing aliquot?	___	___
532	Does operator know the minimum amount of sample required before doing a site analysis? (70-75 mL)	___	___
533	How much time elapses between sample bucket removal and shipment?	______	
534	Operator's contact for technical questions?	______	
535	Operator's contact for shipping problems, supplies?	______	
536	Types of technical problems encountered and how they were resolved? ______________________________ ______________________________ ______________________________ ______________________________		

Inspect the FORF and rain gauge charts for past 10 weeks. Complete Table A-2.

TABLE A-2. RECORDS CHECK

Date Bucket Off	Rain Gauge Precip. in.	Sample Weight Precip. in.	Cond. Distilled Water µS/cm	Cond. Correction Factor	Cond. Sample µS/cm	pH Check Sample	pH Precip. Sample

Compare a FORF with corresponding rain gauge chart.

FORF Precip. record Bucket On _____________ Bucket Off _____________

	Tues.	Wed.	Thur.	Fri.	Sat.	Sun.	Mon.	Tue.
Site Values								
Rain gauge chart Survey Values								

		Yes	No
	Records Check.		
537	Are copies of Field Observer Report Forms (FORF) kept on file?		
538	Examine FORFs. Are they filled in completely?		

		Yes	No
537	Are the FORF entries legible and neat, with no erasures, and errors removed by one line through original data?		
540	Does operator know how to request additional supplies?		
541	Are copies of Belfort rain gauge charts kept on file?		
Are charts documented with:			
542	Date and time of chart installation?		
543	Date and time of chart removal?		
544	Site identification?		
545	Event marks?		
546	Time adjustments?		
547	Compare FORF entries to rain gauge chart amounts as determined by the RTI representative. If there are any noted discrepancies enter on Table 2.		
548	Have the test solutions been measured each time?		
549	Does the measured pH agree with the stated pH within 0.1 pH unit in each instance?		
550	When agreement within specifications is not found, what action does the site operator take? ____________________ ____		
551	Does the site operator have a file of all memoranda and letters issued concerning field operations?		
552	Does the site operator have any questions about the contents of the memoranda and letters?		
553	If question 7 is answered "yes", list the question(s) and the pertinent memoranda or letter.____________________		
554	Does the operator have any questions concerning the quarterly USGS audit of pH and conductivity?		

Comments ____
____

pH

The auditor is to ask the site operator to determine the pH of test solutions in exactly the same way as for a precipitation sample. The auditor is to give the operator the following test solution (contained in a polyethylene bottle) for testing.

- o Solution of simulated precipitation, the same one(s) used to test conductivity meter.

The auditor is to observe the operator carry out his standard procedure for determining pH as given in Section 3.3.3 of Reference (4). The auditor is to allow the site operator to work alone and is to answer the following questions concerning the operator's adherence to standard procedures for calibration of the pH meter and testing of samples.

Data from test to be entered by site operator on a FORF as a normal rain sample.

TABLE A-3. SURVEY RESULTS FOR pH

601 Site pH Meter: Make __________ Model __________

602 Site pH Electrode: Make __________ Model __________

Solution	Site Value (pH units)	Expected or Audit Value (pH units)	Difference (Site-Audit)
603 Site's H_2SO_4 Check Sol'n			
604 Simulated Rain Sample __			

		Yes	No
605	Is electrode furnished by CAL?		
606	How is the pH electrode stored between analysis sessions?		
607	Is pH electrode properly connected to the rear of the meter?		
608	Is the electrolyte fill hole of the electrode open during analysis.		
609	Does the operator rinse the electrode in deionized water and blot off drops prior to use?		

		Yes	No
610	Is meter standardized with pH 7 buffer solution by adjusting STANDARDIZE control?	___	___
611	Is meter response to pH 4 buffer set by adjusting SLOPE control?	___	___
612	Is electrode rinsed with deionized water and blotted between pH 7 and 4 buffers?	___	___
613	Is electrode tip kept from contact with bottom of test tube?	___	___
614	Does site use the 4 ml standard test tubes?	___	___
615	Is pH of electrode test solution determined using two aliquots of solution.	___	___
616	Are any adjustments made to pH meter?	___	___
617	Do at least 2-3 minutes time elapse between inserting electrode and recording final reading?	___	___
618	Is the electrode response slow?	___	___

Conductivity

The auditor is to ask the site operator to determine the conductivity of test solutions in exactly the same way as determined for a precipitation sample. The auditor is to give the operator the following test solutions (contained in polyethylene bottles) for testing.

- Solution of simulated precipitation (the same one used to test pH meter)

The auditor is to observe the operator carry out his standard procedure for conductivity as given in Section 3.3.3 of Reference (4). The auditor is to allow the site operator to work alone and to answer the following questions concerning adherence to standard procedures for internal meter checks, calibration and sample analysis.

Data from test to be entered by site operator on a FORF as a normal rain sample.

TABLE A-4. SURVEY RESULTS FOR CONDUCTIVITY

701 Site Conductivity Meter: Make ________ Model ________ S/N ____

702 Site Conductivity Cell: Make ________ Model ________ S/N ____

Solution	Site Value (μmho/cm)	Audit Value (μmho/cm)
703 Site DI H_2O	________	
704 Site's 0.0005M KCl	________	
705 Simulated Rain Sample (Corrected)	________	________

		Yes	No
706	Does site have a YSI type cell?	___	___
707	Is the YSI type conductivity cell used in the recommended (inverted) manner?	___	___
708	Does site conductivity meter have calibration adjustments?	___	___
709	Is the conductivity meter calibrated before beginning test run?	___	___
710	Is the conductivity cell rinsed thoroughly with deionized water between samples?	___	___

		Yes	No
711	Is the conductivity standard tested before deionized water?	___	___
712	Is the conductivity cell rinsed with an aliquot of sample then another aliquot of the sample added and measured? (YSI type cell)	___	___
713	Are sample conductivity values corrected for the measured value of the conductivity standard (i.e., sample measured x standard value ÷ standard measured value = sample corrected)?	___	___
714	Is the conductivity cell rinsed with deionized water before storing?	___	___
715	How is conductivity cell stored?	________	

Mass

As part of the performance survey, the station operator is to prepare the balance for use and weigh a number of weights to be supplied by RTI.

Weights are to be added to the balance one at a time and the total mass measured after each addition. All data are to be entered in Table A-5.

TABLE A-5. SURVEY RESULTS FOR BALANCE

Site Name ________________________________
Date of Survey________________________________
Operator's Name ____________________________
Surveyor's Name ____________________________

801 Balance Name __________ Balance Model Number ______________

Survey Weight(s) (g)	Total Survey Mass (g)	Balance Reading (g)	Difference, g Balance Reading - Survey Weight

802 Balance Name __________ Balance Model Number ______________

Survey Weight(s) (g)	Total Survey Mass (g)	Balance Reading (g)	Difference, g Balance Reading - Survey Weight

SECTION 8
Quality Assurance Report
NADP/NTN Deposition Monitoring

Section 8 is a reproduction of a previously released report that includes a description of the field operations from 1978 to 1983 and documents the quality assurance programs in effect as of 1986. The page numbers (76-171) at the bottom of the pages have been added to conform with the pagination scheme of the present report.

SECTION 8
Quality Assurance Report
NADP/NTN Deposition Monitoring
Field Operations
July 1978 through December 1983

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Introduction

BACKGROUND

The National Atmospheric Deposition Program (NADP) monitoring network began operations in July of 1978 with seven monitoring stations. The operating details of the new network were outlined in a document titled *A Plan of Research for NC-141 North Central Regional Project On Atmospheric Deposition: Chemical Changes In Atmospheric Deposition And Effects On Agricultural And Forested Land And Surface Waters In The United States* (6). The Network would use cooperating local, state and federal agencies as well as private industry to operate a network of sites according to a single set of protocols. Each site would submit weekly samples to a single central analytical laboratory (CAL) where chemical analysis would be performed. The data from the Network would then be archived and made available to the scientific community as well as to the program participants.

The National Atmospheric Deposition Program is unique in its structure and mode of operation. NADP represents hundreds of interested individuals and many agencies who cooperate voluntarily to operate deposition monitoring sites and to pool data and research efforts under the NADP umbrella. Committees made up of scientists from all the cooperating agencies oversee the various areas of network operations (siting, analytical laboratory, data management and quality assurance) so that network data will continue to be of the highest quality and be available for a wide variety of research needs. Because of this cooperation, NADP has become a focal point for atmospheric deposition monitoring and research in the United States. Part of its success can be attributed to the adherence to the original network design which, in addition to requiring adherence to explicit siting guidelines, following a uniform set of site operating protocols, using only one type of rain and deposition collection device and requiring the use of one central analytical laboratory, requires it's site operators and sponsors to make a long term commitment to the monitoring effort.

Since 1978 the Network has grown to more than one hundred and ninety stations and includes sites identified as National Trends Network (NTN) sites. The Quality Assurance Plan (15) has refined the quality assurance commitments made in the original *Plan for Research* and reaffirmed the quality assurance goals of the monitoring network.

This report discusses the current status of implementing the NADP Quality Assurance Plan, describes the available publications which document current NADP procedures, and, characterizes the NADP Field Operations through 1983.

REPORT HIGHLIGHTS

The operation of field sites within the NADP network has been successful in spite of the fact that each site is ultimately responsible on a volunteer basis for producing quality results. Quality assurance tools have been developed by the program, most notably by the Central Analytical Laboratory of the Illinois State Water Survey, which allow sites to evaluate the quality of their effort almost immediately. Periodically, audit programs have been run to verify that sites are using these tools effectively. Manuals, training programs, a field form with built in quality checks, audit solutions and full time site liaison personnel at CAL are but a few of the resources available to sites.

The only apparent shortcoming of this decentralized approach to quality assurance in the field site operation has been the the lack of centralized reporting of quality assurance audit information. Quality assurance information has not been given the same reporting priority as wet deposition chemical analysis and precipitation data. This information, therefore, oftentimes only resides within the agency that performed the audit leaving non-agency scientists wondering if any quality assurance checks are being conducted by the network. When this information is finally reported by the agency, it often represents only one small part of the overall quality assurance effort. The initiation of this and subsequent quality assurance reports should improve and centralize the reporting of network quality assurance information.

Within this report, a list of the current quality assurance programs in effect within the NADP/NTN network is presented. The list identifies the agency responsible for conducting the program. The report identifies areas where further research is needed to compliment NADP standard practices (i.e. site representativeness, sample integrity, precision and accuracy estimates, and, seasonality estimates). Network evaluations of site representativeness and data completeness are discussed using five tables to illustrate some of the innovative methods the network is using to address these important research issues. Annual network summaries are presented showing that the Network is meeting the performance goals that were reaffirmed in the Quality Assurance Plan. These summaries include tables of regional collector and rain gage performance, 'network system blank' information and estimates of collector and rain gage precision and accuracy. Finally, the report gives an overall view of site performance through an analysis of the screening and flagging notes and codes that are assigned to each data record after all quality assurance checks have been made.

Network Quality Assurance

In the summer of 1984 the National Atmospheric Deposition Program formally adopted a quality assurance plan. This was by no means the first attempt at implementing quality assurance procedures in the monitoring network. Rather, the plan represented a more formal mechanism for recognizing the numerous quality assurance and quality control tasks that have been performed by network personnel since the programs inception. Because of the unique structure, size, and operational characteristics of the NADP monitoring network, innovative modifications to existing quality assurance practice often had to be developed. Each agency that directs a monitoring network activity is responsible for developing applicable quality assurance procedures for that task. These quality assurance procedures are then reviewed and accepted by the various NADP Technical Subcommittees responsible for overseeing each network function. Typically this would be the 'Methods Development and Quality Assurance Subcommittee', the 'Site Criteria and Standards Subcommittee', or the 'Quality Assurance Steering Committee'.

The NADP Quality Assurance Plan (15) summaries the goals and key components of the network's quality assurance program. It is not intended to replace the standard operating procedures (SOP's) used in the network, but instead recognizes that these key pieces of documentation (SOP's) have been or will have been assembled by each responsible agency. Documentation for many of the various quality assurance/quality control procedures used within the NADP monitoring network have been reported in the scientific literature, at professional and technical meetings and in various participating agency reports. Unfortunately, no network document exists which details all of these procedures. Because quality assurance responsibilities are decentralized, it has also been difficult to document the achievement of data quality goals and objectives within the NADP network. Though estimates of precision, accuracy, representativeness and completeness have been determined, they are often 'lost' in the various scientific and agency reports. Others, for lack of an audience, have never made it to publication and only appear in network memos and notices supplied to site operators, supervisors and/or sponsors.

The quality assurance reports will evaluate three major areas of network operations- field, laboratory and data management as well as report on overall network quality. The reports are meant to tie the various organizational and operational quality assurance programs together using these four major areas as themes. The various agency programs that comprise the NADP Quality Assurance Program are listed by organizational task on the next page.

Table 1. NADP/NTN Quality Assurance Programs

Task no.	Task Name	Operating Agency	Program Name
FIELD SITE OPERATIONS:			
1.	Quality Control of Field Operations	CAL	CAL Site Interactions
2.	Quality Assurance of Field Operations	CSU	Across Site Network Analysis
3.	Systems and Performance Audit of Field Operations	EPA (RTI)	NADP/NTN Site Visitation Program
4.	Quality Assurance Of Site Chemical Analysis	USGS	Intersite Comparisons.
LABORATORY OPERATIONS:			
5.	Laboratory Quality Control	CAL	CAL QA program
6.	Laboratory Quality Assurance	CAL	Interlaboratory Comparisons.
7.	Laboratory Systems Audit	NADP Subcommittee 2	
DATA MANAGEMENT:			
8.	Quality Control of Site/ Chemical Analysis Data through Data Management	CAL	Data Screening and Coding
8.	Quality Control of Site/ Chemical Analysis Data through Data Management	CSU	Data Screening, Coding and Summary Reporting
9.	Quality Control of Data Management: ADS	PNL	
10.	Quality Assurance of Network Data Management	QA Steering Committee	Systems and Performance Audit of the Data Management Program
NETWORK OPERATIONS :			
11.	Performance Audit of Field and Laboratory Chemical Analysis	USGS	Blind Audit Program
12.	Laboratory Quality Assurance	USGS	Interlaboratory Comparisons.
13.	Performance Audit of the Network	CSU	Network Intercomparison's with CANSAP/CAPMoN
14.	Special Studies which assess various components of Network performance	ALL	Published Scientific Research Results
15.	Systems Review of Deposition Monitoring Network	TASK GROUP 4	NAPAP Annual Review
15.	Systems Review of the Deposition Monitoring Network	QA Steering Commit.	IR-7 Annual Review

CAL - Central Analytical Laboratory, Illinois State Water Survey
CSU - Natural Resource Ecology Laboratory, Colorado State University
EPA - Environmental Monitoring Systems Laboratory, Environmental Protection Agency
PNL - Battelle's Pacific Northwest Laboratory
RTI - Research Triangle Institute, Research Triangle Park, NC
USGS - National Water Quality Laboratory, U.S. Geological Survey
Task Group 4 - National Acid Precipitation Assessment Program (NAPAP)
QA Steering Committee - National Atmospheric Deposition Program

Field Operations

The achievement of the NADP goals and objectives is dependent upon the establishment of and continuous operation of a long-term network of regionally representative monitoring sites. It has long been proposed that regional representativeness be determined through the implementation of a site certification program. Such a program would not only evaluate site locations but also indicate whether sufficient data was being produced at each site and if the data was of high enough quality to be considered regionally representative.

Though NADP has not yet established site certification standards, some components of such a program have been used in the program and can be evaluated. These components deal with evaluating how the location of each site compares to an established set of siting criteria (Representativeness and Site Selection), evaluating the completeness of the information being collected at each monitoring station (Completeness) and evaluating site performance (Performance).

REPRESENTATIVENESS

Determining the similarity between key regional characteristics and those same characteristics found at each site would be a straight forward way of determining a sites regional representativeness. The actual comparison is difficult however, due to the lack of agreement on what constitutes key regional traits and a lack of definition of what constitutes a region when one is characterizing a geographic area as large as the United States or North America.

The NADP program has reached a consensus on what constitutes key characteristics at a site (14) and currently evaluates representativeness by auditing these key characteristics at each site. This approach hypothesizes that the extent to which a site departs from this agreed upon set of criteria constitutes a measure of site representativeness. The criteria evaluate 1) the spatial relationships of objects within 30 meters of the collector, 2) the ground cover, topography and meteorology at the site, 3) the local emissions and land use to 1 kilometer surrounding the site, and 4) the point and area emissions within 50 kilometers of the site. The criteria are detailed in the NADP/NTN Site Selection and Installation Instruction Manual (14). When defining a region, political geographic boundaries (states), meteorological regimes, equal area grids, emissions and land use groupings all qualify as acceptable definitions of a region. As one would expect, the 'correct' definition of a region depends completely upon the use to which the data will be put. The analysis of the data then, will ultimately determine whether the sites are representative.

Robertson and Wilson (23) evaluated other methods of representativeness when designing the National Trends Network. In the NTN design document (23) they discuss practical solutions to the problems encountered when trying to design a large network around regional characteristics. The discussion forms the basis for the ecoregion design of the National Trends Network. Because of the similarities and often concurrency between NTN and NADP, this presentation also serves as a discussion of some of the representativeness strategies that have been debated in both the the NADP and NTN programs.

The ecoregion design is an adaptation of work done by Bailey and others (1, 2). It defines areas according to ecological similarities, i.e. ecoregions. Abiotic and biotic factors such as climate, vegetation and soils are evaluated and grouped into a numbered classification scheme. General characteristics of the scheme and a map of the Domains and Divisions used in this report are reproduced on the following two pages (from Robertson and Wilson Table 1 and Figure 1 [23]).

Divisions are further subdivided into Provinces, which designate areas of uniform climate and zonal soils, and into Sections which designate areas within provinces that depart in some minor way from the province and/or have a uniform vegetative climax type. In areas where two or more climax associations need to be represented but other characteristics remain similar, prefixes (A, M, and P) are used to distinguish between the different associations. Usually these associations represent altitudinal differences.

In this report those ecoregions that have been designated with an A or M are collectively referred to as mountains within their respective Domains. The ecoregions that have been designated with a P however, are not distinguished from their sectional or provincial classification.

Table 2. **General Environmental Characteristics of Domains and Divisions (from Robertson and Wilson [23] after Bailey 1976)**

Domain	Division	Temperature	Rainfall	Vegetation	Soil*
2000 Humid Temperate	**2100 Warm Continental**	Coldest month below 0 ° C, warmest month < 22 ° C	Adequate throughout the year	Seasonal forests, mixed coniferous	Gray-Brown Podzolic (Spodosols, Alfisols)
	2200 Hot Continental	Coldest month below 0 ° C warmest month > 22 ° C	Summer Maximum	Deciduous forests	Gray-Brown Podzolic (Alfisols)
	2300 Subtropical	Coldest month between 18 ° C and -3 ° C, warmest month > 22 ° C	Adequate throughout the year	Coniferous and mixed coniferous-deciduous forest	Red and Yellow Podzolic (Ultisols)
	2400 Marine	Coldest month between 18 ° C and -3 ° C, warmest month < 22 ° C	Maximum in winter	Coniferous forest	Brown Forest and Grey-Brown Podzolic (Alfisols)
	2500 Prairie	Variable	Adequate all year, excepting dry years, maximum in summer	Tall grass parklands	Prairie soils, Chernozems (Mollisols)
	2600 Mediterranean	Coldest month between 18 ° C and 3 ° C, warmest month > 22 ° C	Dry summer, rainy winters	Evergreen woodlands and scrubs	Mostly immature soils
3000 Dry	**3100 Steppe**	Variable, winters cold	Rain < 50 cm/yr.	Short grass, scrubs	Chestnut, Brown soils and Sterozems (Mollisols, Aridisols)
	3200 Desert	High summer temperature, mild winters	Very dry in all seasons	Scrubs and sparse grasses	Desert (Aridisols)
4000 Humid Tropical	**4100 Savanna**	Coldest month > 18 ° C, annual variation < 12 ° C	Dry season with < 6 cm/yr.	Open grassland, scattered trees	Latosols (Oxisols)

* Names in parentheses are soil taxonomy orders

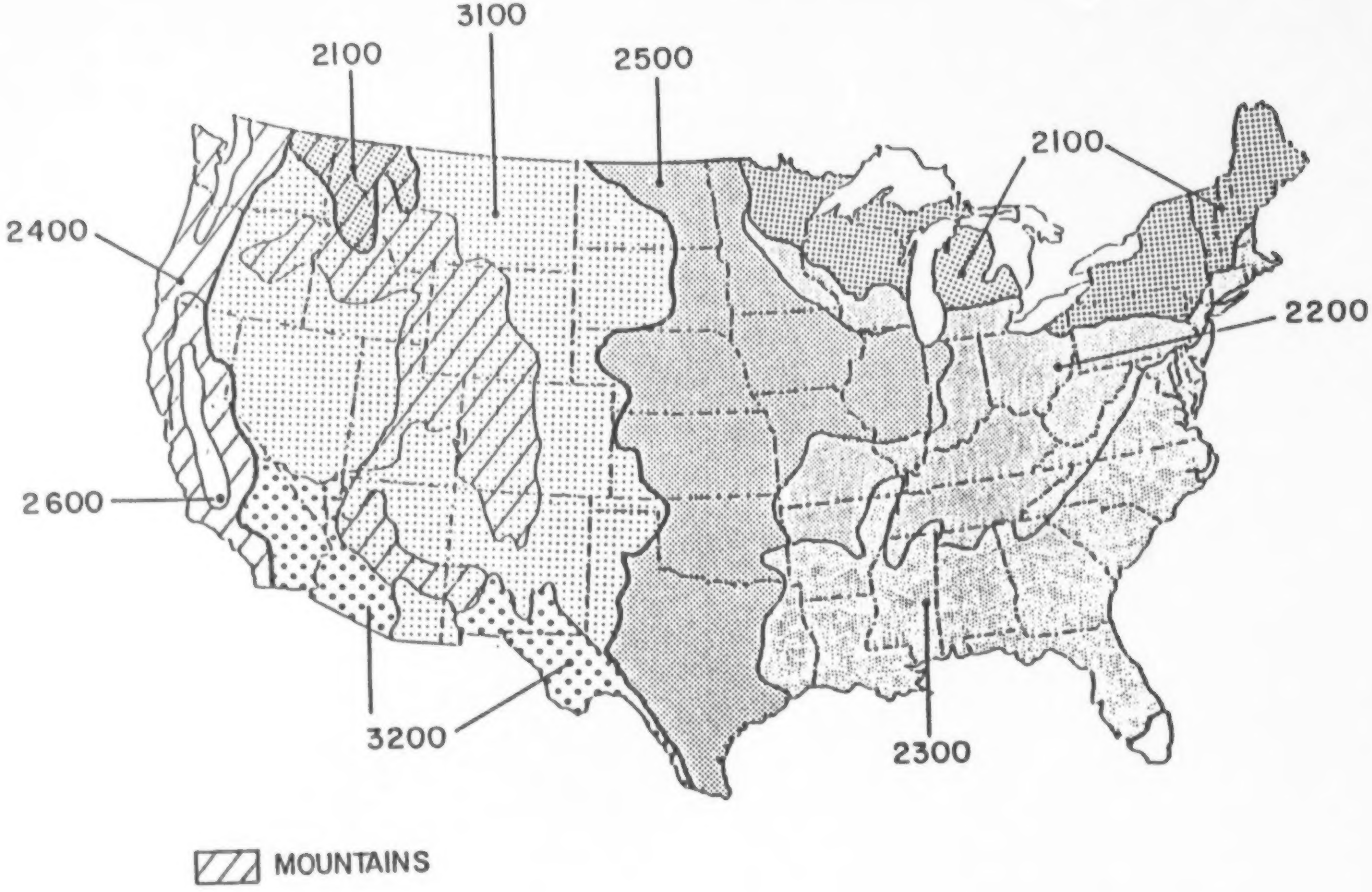

3100
2100
2500
2100
2400
2200
2600
3200
2300
MOUNTAINS

Fig I. Ecoregions of the United States (After Bailey, 1976)

In evaluating and reporting field site quality assurance information it is important to identify quality assurance programs which help point out regional differences in data quality or that point out bias in estimates of precision, accuracy and completeness due to regional performance characteristics of the experimental design of the network. Since the NTN has already designated the ecoregion as a useful type of regional classification of sites, the ecoregion grouping will be used throughout this report to help identify regional differences in data quality. The ecoregion grouping is only one of many that are available for this type of analysis. Keep in mind, that the the type of regional quality assurance analysis performed, like the definition of a region, completely depends upon the use of the data.

Regional representativeness is an area of research that needs much further attention. In the statistical sense, areal density requirements need to be established perhaps using probability statistics to help quantify error estimates made by using selection criteria based upon geographic, topographic, physiographic or other stratifications of site data. The relationships of spatial positioning of sites relative to other objects and emission sources needs to be verified by field studies to support site criteria that have evolved from generally agreed upon hypotheses. Most certainly, existing data both within the NADP program and between other networks need to be examined to determine if some of the hypotheses currently in use are valid.

SITE SELECTION

Sites may be admitted into the NADP network in one of two ways. In the most common method a sponsor contacts the Coordinator's office and is given consultation over the telephone as to the type of site that would be acceptable as a wet deposition monitoring site. The sponsor is advised of the long term commitment involved in joining the Network and of the strict equipment and laboratory analysis requirements as well as the cost of participation. The sponsor is then sent a 'startup packet' which includes the NADP/NTN Site Selection and Installation Instruction Manual (14), the NADP Site Operation Instruction Manual (13), a blank Site Description Questionnaire (14), a standard contract and some background information. The background information includes equipment purchasing details, a current list of cooperating agencies, an organizational chart, a map of the Network and a brief historical narrative on the NADP and NTN program.

The sponsor completes the Site Description Questionnaire and submits it for approval to the Coordinator's office. Here the site description, along with the required site pictures, detailed site sketch and topographical map is reviewed for completeness and adherence to the siting requirements of the network. If the proposed site is unacceptable or duplicates another site the sponsor is encouraged to propose an alternate site. If a site is accepted the sponsor is directed to CAL to obtain start up supplies. A copy of the Site Description Questionnaire is forwarded to CAL. The original is archived at the Coordinator's Office. CAL informs the Coordinator's office via a standard form when the site has actually started. The form is archived at the Coordinator's office.

The second method by which sites are admitted into the Network is characterized by, but not limited to, those locations that were designated as new NTN sites after visits by United States Military Academy personnel (23). Because of time constraints, some site locations are pre-approved -in the NTN case by Task Group D on Deposition Monitoring, of the National Acid Precipitation Assessment Program (NAPAP)- and order start-up supplies directly from CAL. Site Description Questionnaires are completed after the site has started operation.

The first method of admitting sites is preferred since the second method does not guarantee that a site is in fact set up at the location specified by the approving authority or that instrumentation has been installed to meet the established criteria for the 30 meters surrounding the collector. Site deficiencies such as fencing that has been installed too close to the collector, rain gages installed to close to the collector or the dense packing of instrumentation at the site can not be identified or corrected until after the the site has begun operating.

The success of the site selection process is evaluated in the following three tables. The tables reflect some of the ways in which the quality of site selection has been viewed in the past. Early in the program sites were designated as either 'standard' or 'nonstandard' based upon all available site information at the Coordinator's Office during the preparation of quarterly data reports of precipitation chemistry. Included in the nonstandard site list were those sites that were located on a roof, that were using a non-approved collector or that were not following a year-round Tuesday to Tuesday sampling schedule (i.e. sampling intermittantly or on a day other than Tuesday). The classification of 'nonstandard' was based upon the belief that data from sites having these problems are best not compared with other network site data. It was recognized that nonstandard data however, does comprise a long term record of information that can be useful in those instances where site to site comparisons are not as important (i.e. the long term trends of a single site). Table 3 lists by year the number of sites that have been or would have been included in the Nonstandard Data Sets portion of the quarterly NADP and NADP/NTN Data Reports of Precipitation Chemistry.

Table 3. Nonstandard Sites in the NADP/NTN Network by Year

Year	1978	1979	1980	1981	1982	1983
Total Stations	22	39	82	96	110	143
Nonstandard Stations	2	3	12	12	8	5
Percent Nonstandard	9	8	15	13	7	4

Concurrent with the above evaluation, which began with the publication of the third quarter, 1980, quarterly Data Report of Precipitation Chemistry, paper audits of site documentation were conducted by the Site Selection and Certification Subcommittee of the NADP Technical Committee. Table 4 is based upon these detailed reviews of the Site Description Questionnaires and the Supplemental Site Description Questionnaires (see Appendix D). During these reviews sites were identified as to whether they met the siting criteria outlined in the Site Selection and Installation Manual (14) and as to whether they had the required collector, rain gage and event pen.

Table 4. Site Description Questionnaire Audits

	Audit Dates		
Parameter	AUG 81	APR 82	JAN 84
Number of Sites Reviewed	89	103	151
Improper siting	0	0	0
Nonstandard rain gages †		22	2
No event pens †		36	16‡
No documentation	2	0	2

† includes information obtained during site visits.
‡ includes 7 stations that have since been closed

In Table 3 nonstandard stations comprised approximately 10% of the network. The worst year was 1980 when approximately 15% of the sites in the network were nonstandard during some part of the year. In Table 4 however, none of the sites were identified as having siting problems, even-though some stations had been located on a roof. Note that the audits summarized in the Table 3 evaluation did not consider non-standard rain gages or lack of event pens as a means of classifying sites as nonstandard.

Discrepancies between Tables 3 and 4 are largely due to the variety of Site Description Questionnaire forms used to collect the information. The first questionnaires, for instance, did not ask if a site had an event pen or if the collector was located on a platform or roof. Further, site sketchs and pictures were not mandatory in the early days of the program. As a result, some of the sites were not identified as not meeting siting criteria or as not having proper equipment. Additionally, changes made at sites after the initial site description was submitted often remained undetected until a site visitation or special inquiry alerted the Coordinator's Office or CAL to a problem. For these reasons the information contained in Tables 3 and 4 only give a rough estimate of success of the siting efforts of the NADP program. Both tables do show, however, that progress was being made towards reducing the number of sites that could be considered as not regionally representative.

Beginning in the fall of 1982 and ending in early 1984, all of the NADP/NTN sites operating in the contiguous United States were visited by a member of the faculty of the United States Military Academy at West Point (USMA). This program, sponsored by the U.S. Geological Survey, audited both siting and field operations, and, re-documented and photographed each site (24). Site deficiencies noted by the visitation team were presented and discussed with the Coordinator's Office. Based on these discussions, remedial action was initiated by the Coordinator's Office. The deficiencies noted by the visitation team and the recommendations of the Coordinator's Office are summarized in Table 5.

Table 5. Summary Of Site Deficiencies Identified By West Point (USMA) Site Visitations And Remedial Action Recommended By The Coordinator's Office

Findings	no.	%
Number of Sites Visited	111	
Deficiencies:		
Not meeting regional requirements	19	17
Not meeting local requirements	42	38
Not meeting on-site requirements	88	79
Using improper collector	3	3
Using improper rain gage	2	2
Without event pens	15	14
Recommended Action:		
No action required	72	65
Make minor adjustments	14	13
Require move	20	18
Should close	5	4

Table 5 presents the clearest picture of the effectiveness of the NADP siting efforts. The evaluations from which this information was taken comes from an on-site evaluation by a team of objective observers. Though, in the worst category, 79% of the sites did not meet on-site siting requirements, only 22% of the sites were recommended to move or close. This came about because in half of the 20 sites recommended to move, suitable locations were identified less than 500 meters from the original location. In fact, 86% of the sites were determined to be suitable for regionally representative monitoring if minor equipment location changes were made.

The sites deficiencies identified by the West Point visits may, in fact, be only the difference between a 'good' site and an 'excellent' site, considering the main problems identified by the visitation team. Clustering of co-located equipment and site clutter accounted for 80% of the on-site problems. Seventy-two percent of the problems alone can be attributed to the required rain gage being located too close to the collector. Under local requirements, the most common problem found was with sites being located in close proximity to roads and parking areas. The type of road or lot surface (paved or dirt) and the traffic volumes carried, largely determined whether the site was recommended to move, close or was considered not significantly affected. It is interesting to note that only 14% of the sites met all of the siting criteria. A more detailed presentation of the West Point Site Visitation Summary is located in Appendix A.

The above discussion suggests that possibly as many as 35% of the monitoring sites in the network may have been sited in violation of established siting criteria. The Site Description Questionnaire and its review by the coordinator -at least early in the program- was not able to detect these deficiencies. Further, the most common problem found in siting a monitoring station is the dense packing of co-located equipment - most notably the rain gage.

In light of these findings, it cannot be emphasized enough that sites need to be visited DURING installation so that these 'on-site' problems can be avoided. This is a requirement in the QA plan. Unfortunately, funding has not been made available to make this requirement a reality at this time.

COMPLETENESS OF RECORDS

The NADP monitoring network's success in producing a high proportion of samples that can be used for long term trend analysis, is evaluated by examining the completeness of the records that are produced at each site. The significance of missing network information can be demonstrated by looking beyond simple record counts. Tables 6 and 7 outline the overall completeness of records collected by the NADP network. The tables use the data selection criteria for Annual Summaries of Precipitation Chemistry (16), developed by the Data Management and Analysis Subcommittee of the NADP Technical Committee, and other annual site statistics to provide an overview of site record completeness that spans the five and one half year operating history of the NADP.

Table 6 summarizes by year, on a network basis, the number of weeks data were not sent to the network, the number of weeks precipitation data were not recorded, the number of weeks bucket volumes were the only measure of precipitation available, the amount of time valid precipitation data is available at the average site, the collection efficiency of the wet/dry collector in relation to the standard rain gage at the average site, and the number of valid samples produced by the average site.

Table 6. Completeness of Records by Type and Year for the NADP Network

	Records in Data Base (%)			Average Records per Site per Year (%)					
	Missing		Bucket Volume Substituted	Precipitation Coverage		Collector Catch Efficiency		Valid Samples	
Year	Sample Records	Precip. Records		Average	Median	Average	Median	Average	Median
1978	13.8	26.4	32.7	23.6	22.0	87.9	93.2	21.1	18.4
1979	3.8	15.9	21.6	73.0	80.0	91.3	94.1	66.9	69.3
1980	3.2	20.8	27.1	61.9	62.7	92.6	93.3	53.9	51.2
1981	2.4	5.1	12.7	84.8	100.0	92.5	95.3	69.8	81.0
1982	1.5	3.1	11.7	89.8	100.0	91.0	93.9	74.1	83.0
1983	0.7	2.6	10.4	81.7	100.0	88.6	94.1	68.0	79.2

The table indicates that NADP has made considerable progress since 1978 in reducing the number of unaccounted for sampling intervals and in reducing the amount of weeks where precipitation records are missing. In the first year of the program 13.8% of the sampling weeks were unaccounted for. This percentage dropped to 3.8% when it was made clear to operators that the program expected to hear from them weekly, no matter what! Steady progress has been made since those early years so that in 1983 only 0.7% of the sampling records remain unaccounted for.

Similar improvements can be noted in the missing precipitation records column and in the precipitation coverage columns. However, the large improvement in these numbers in 1981 is somewhat misleading in that precipitation data prior to 1981 was routinely excluded from the NADP data base if the sample was not a valid sample. This problem existed in the NADP data management programs until mid-1981. At that time the error in programming was fixed and early 1981 precipitation was restored to the NADP data base. Earlier data suffering from this problem was only recently updated. Unfortunately the data upgrade was not available for this report. Depending on the year then, this causes reported average site precipitation coverage estimates from 1978 through 1980 to be low by 2.5 to 7.3 percent. (see appendix B for more detailed information). In all, approximately 5% of the total samples during the the 1978-1980 calendar years are affected. The error also distorts the weeks where sampler bucket volume has to be used in lieu of precipitation records as the only means of determining precipitation for the weekly sample. As can be seen by the table, bucket substitutions mimic the missing precipitation records. The difference between the two however, demonstrates that even when precipitation records are available, some 7% of the records are invalidated requiring that the bucket volume substitution be made in approximately 12% of the network records.

The proportion of valid samples at sites has also been steadily increasing. Most of the progress reported can be attributed to additional staffing and additional quality assurance activities at CAL. Some of the more significant improvements made during this summary period include: The hiring of a full time site manager to serve as the primary laboratory-site liaison; the initiation of site operator training courses in the fall of 1980 and the revision of the Field Observer Report Form in mid 1981 and Site Operation Manual in Early 1982 (13).

Collector catch efficiency is the one area where there has been little if any improvement. This is not surprising since no basic design changes in either the collector or the rain gage were made during the period of summary. Minor improvements to the collector sensor and motor box were made during this time period, however, these improvements were aimed at making the collector more reliable during extreme conditions (e.g. freezing rain, lightning). Median values especially illustrate that collector catch efficiency has remained constant in the program and at a level reported in the literature by others (see Table 8; Catch Efficiency is discussed in more detail in the Performance section of this report).

Table 7 presents on an annual basis, the average value, in percent, of sites passing each of the annual summary criteria established by the NADP Data Management and Analysis Subcommittee (16), along with the average value, in percent, of sites passing all of the criteria. The four annual summary criteria form the basis for the decision to include the data from a site in an NADP/NTN annual summary. In two of the criteria, median values, marked with an asterisk (*) are presented in lieu of averages to remove the affect of network growth on the average site statistics. Values have also been adjusted to reflect only those sites which had operated for a full year.

Criteria 1 and 2 assure that measurements on valid wet deposition samples and of precipitation amounts were reported for a minimum acceptable fraction of the year. This requires a properly operating wet/dry collector and rain gage. Criteria 1 and 3 assure that there was precipitation chemistry to represent not only 75% of the summary period, but also 75% of the precipitation that was estimated to have occurred during the summary period. The fourth criterion sets an acceptable range for the collection efficiency of the wet/dry collectors relative to the rain gage.

This assures some consistency in the operation of both the rain gage and the collector. The criteria are listed below.

Criteria 1.

There must be valid samples for at least 75% of the summary period.

Criteria 2.

For at least 90% of the summary period, there must be precipitation amounts either from the rain gage or from the sample volume.

Criteria 3.

There must be valid samples for at least 75% of the total precipitation amount which was reported for the summary period.

Criteria 4.

For the entire summary period the total precipitation from the sample volume must be at least 75% of the total precipitation from the rain gage for all valid samples where both values are available.

Table 7. Sites Passing Annual Summary Criteria

Number Of Sites			Percent of Sites Passing The Annual Summary Criteria				
	Full*		Criteria Number				
Total	Year	Year	ALL	1*	2*	3	4
22	0	1978	0	0	0	95.4	0
37	22	1979	50.0	72.7	50.0	94.6	97.3
82	36	1980	41.7	66.7	47.2	92.7	97.6
98	77	1981	64.9	74.0	93.5	81.6	96.9
110	95	1982	68.4	73.7	93.7	80.0	96.3
143	104	1983	73.1	81.7	97.1	76.9	91.6

* Based upon sites that had operated for one full year.

As can be seen in Table 7, the number of sites meeting all of the annual summary criteria is increasing. For sites that score lowest, the problem is not generating a high proportion of valid samples (criteria 1). The problem does not, however, appear to be related to collector catch efficiency (criteria 4) or precipitation coverage (criteria 2) both of which exceed the 75% and 90% target levels established by the network. Finally, the proportion of sites meeting all summary criteria in earlier years can be increased by correcting the precipitation data handling error described previously. In the Performance section of this report, data will be presented which will point out the fact that invalid samples result not only from operator error, but, more frequently from equipment malfunctions.

A more complete listing of annual site summary statistics is presented in appendix B.

PERFORMANCE

Field site performance is evaluated within the NADP program through equipment and operator surveys; through comparisons of field and laboratory sample weights, pH and conductivity measurements; and through performance audits which test the overall response of selected parts of the field site operation against a predetermined result. Performance evaluations build upon the experience of others (5, 8, 11, 21, 25, 28, 29, 30, 33) and generally support the equipment and operating protocol choices made early in the program. A one time field performance audit, the West Point Site Visitation Survey, was the only attempt within the NADP to conduct a comprehensive field site audit during the 1978-1983 sampling years. This type of audit was initiated on a permanent basis beginning in 1985.

Equipment for which performance information is routinely collected includes the Aerochem Metrics Wet/ Dry Collector, rain gage, pH meter, conductivity meter and balance. These are the primary pieces of equipment necessary to carry out the NADP sampling protocols. Operator performance is evaluated primarily through the critical review of the NADP Field Observer Report Form which accompanies each weekly deposition sample. Included on the form are the daily precipitation records for the site, field sample bucket weights, field chemistry measurements and quality assurance checks performed by the site operator each time a sample is collected.

Comparisons of the sample weight, pH and conductivity between field and laboratory are routinely used to troubleshoot site deficiences. The interpretation of this information is presented as a quality assurance tool to explore some examples of system bias within the NADP program.

Performance audits have been used primarily to test field laboratory performance. Both internal and external audits have been used although, to date, the audits have not been done on a regular schedule nor have they always included all sites.

Wet/ Dry Collector Performance

Performance evaluations of the Aerochem Metrics Wet /Dry Collector have been published in various journals, reports and conference proceedings (5, 8, 11, 21, 25, 28, 29, 30, 33). The studies use precipitation capture (catch) efficiency, reliability of operation, effectiveness in preserving sample integrity and precision between collocated collectors as the means of evaluating performance. These same techniques have been employed within the NADP program to confirm the previous experiences and to demonstrate the continuing quality of the collector at each site.

COLLECTOR CATCH EFFICIENCY

Figure 2 is a map of the average weekly winter catch efficiencies of the Aerochem Metrics Wet/ Dry Collectors averaged by site over the period 1978-1983 in the NADP monitoring network. Figure 3 is the same map showing only summer weeks. Both maps illustrate the catch efficiency of the Wet/ Dry collector in relation to the Belfort rain gage collocated with the collector at each NADP site. This rain gage has been adopted by the network as it's standard rain measuring device.

Figures 2 and 3 illustrate the fact that weekly catch efficiency is both seasonal and regional. Seasonally, the winter weeks tend to have poorer catch while regionally, the Great Plains and Prairies tend to show the greatest seasonal differences. This is not surprising since wind, snow, and to a lesser degree, a higher frequency of low precipitation occurrences at these generally unsheltered sites all combine to lower the effectiveness of the Aerochem as a precipitation collection device. Regional differences are only noticeable in the winter months, however, as summer catch is close to 100% in all regions. On an annual basis, this creates a seasonal bias in the data from those areas where substantial amounts of precipitation occur during winter months. The bias is proportional to the missing winter collector volume.

Figure 2. Winter Isopleth Map of Catch 1978-1983

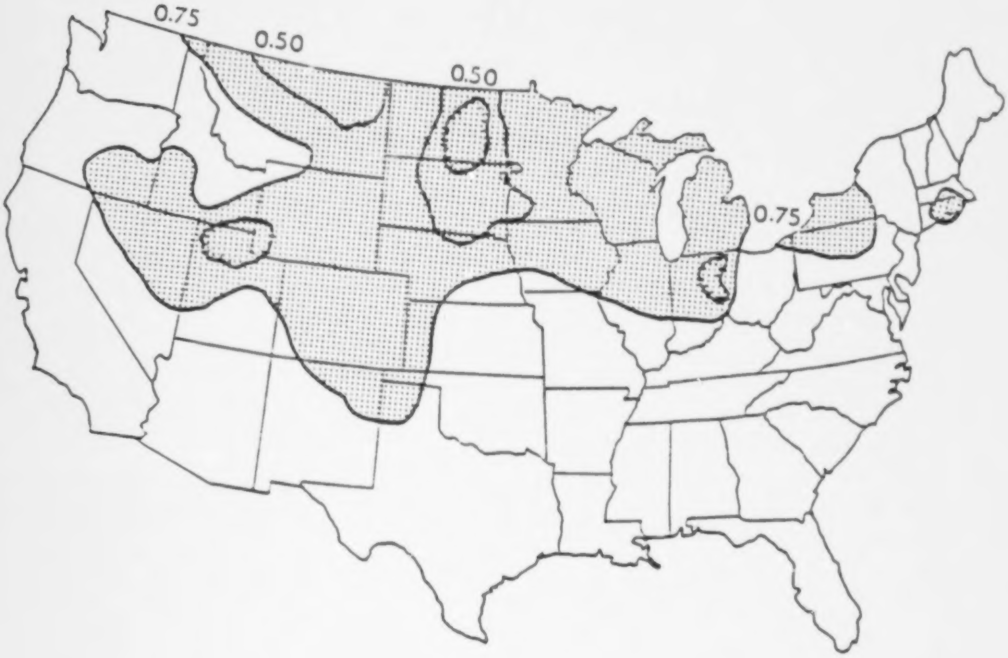
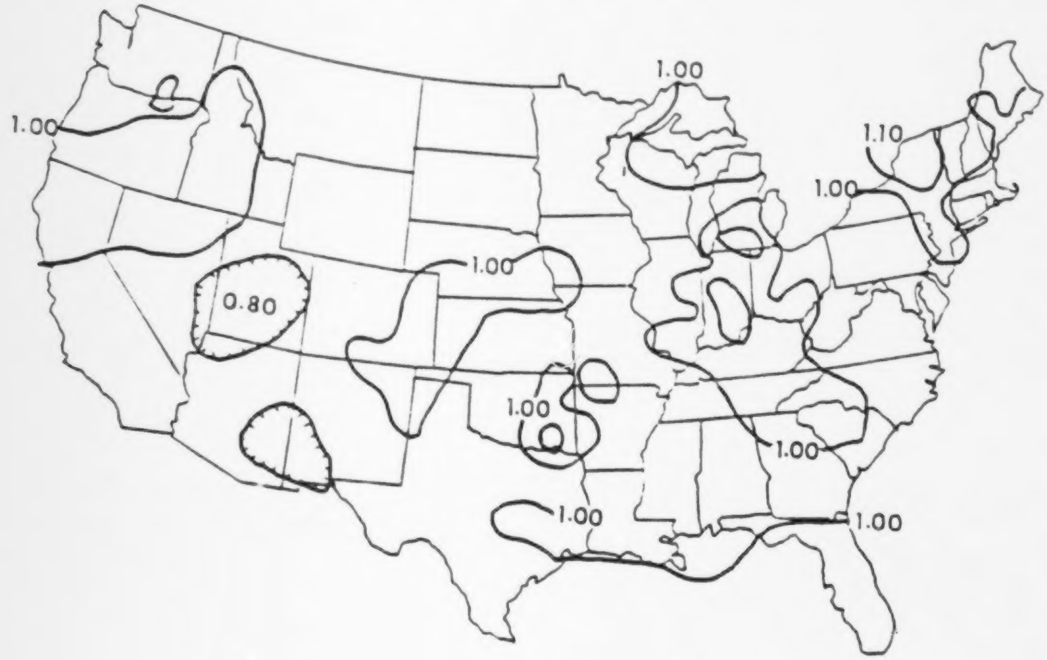

0.75
0.50
0.50
0.75

Figure 3. Summer Isopleth Map of Catch 1978-1983


1.00
1.00
1.10
1.00
1.00
0.80
1.00
1.00
1.00
1.00

Haasz (11) has shown that the Aerochem bucket design contributes to lowered catch efficiences when high winds alter the angle and velocity of snow- and presumably some rain droplets- approaching the bucket. He has also shown that during periods of wind and high snow accumulation, the reduced bucket depth may make the accumulating snow conducive to saltation thereby causing reentrainment of the snow and/ or loss of further accumulation. Another contributor to lowered catch is the original design of the Aerochem sensor. In a 1980 spring site operator survey, seventeen of thirty-eight sites reported a bridging of snow over the sensor such that an 'igloo' was formed. Further precipitation failed to trigger the sensor during these episodes and resulted in poor catch. Replacement sensors with a smaller overall surface area gradually replaced the old style sensors beginning in the winter of 1981 (note- the grid area on the sensor remained the same while the overall size of the sensor was reduced). These new style sensors eventually became the standard on Aerochem models. The same site operator survey noted that twenty-two of thirty-five sites had experienced cases of the foam lid seal freezing to the bucket rim thereby resulting in lower catch. While a permanent solution to this problem was not readily available until 1985, the problem was noted and each site was advised as to interim solutions to the problem. These included light bulbs in a peaked snow roof and heat tape surrounding the bucket receptacle. In spite of these deficiencies, both de Pena and Bowersox (21) and Galloway and Likens (8) found this style of collector superior to other commercially available alternatives.

Table 8 presents collector catch efficiencies previously reported and catch efficiencies reported by NADP in similar locations. Efficiencies reported are simple arithmetic averages of monthly or weekly samples or events taken from HASL type (Aerochem style) collectors that operated at each location. The site average reported is the mean of the individual site averages.

Table 8. Catch Efficiencies Reported in Previous Studies and for Selected NADP Sites

Previous Study	No. of Sites and Location		No. of Samples and Interval		Catch Efficiency (%)				
					Overall	Spring	Summer	Fall	Winter
Bogen (5)	1	Samoa	25	daily	96				
de Pena (21)	1	Penn State, PA	56	event	108				
Galloway (8)	1	Ithaca, NY	9	monthly	86				
Schroder (25)	1	Raleigh, NC	50	weekly	97	99	106	96	100
Volchok (33)	1	New York City	40	monthly	94	96		91	
NADP	1	Samoa	164	weekly	100		89		124
NADP	1	Penn State, PA	28	weekly	98		102		95
NADP	1	Aurora, NY	227	weekly	84		91		67
NADP	4	Raleigh, NC							
		a) RTI	85	weekly	95		96		95
		b) RTP	114	weekly	90		92		89
		c) Finley Farm(a)	227	weekly	91		96		86
		d) Finley Farm(b)	59	weekly	92		98		91
1978-1983 NADP	143	all weeks	15494	weekly	91		97		81

For the four NADP stations reported in Table 8 that operated in close proximity to locations where catch efficiencies have been previously reported, NADP catch efficiency averages ranged from 10% lower, at Penn State, to 4% higher, at Samoa. Lowest overall catch values in both NADP and the literature are reported in the suburban New York locations. Summer-winter catch efficiency comparisons in the North Carolina and New York City locations support the NADP data in figures 2 and 3 that shows seasonal differences in catch, though Galloway (8) reported no significant difference in catch between snow events and rain events.

The overall NADP experience at its 143 sites has not been substantially different than what has been reported previously, in spite of the fact that NADP is a much more geographically distributed network.

RELIABILITY

Reliability of the collector as measured by collector malfunctions can be used to evaluate the utility of the collector for network operations. Like catch efficiency, regional differences in sampling coverage due to differences in collector reliability can create regional uncertainties in annual site statistics. Table 9 presents the average per year, of the sum of motor box, clutch and sensor failures per site within the NADP network. The averages are given by ecoregion division (1, 2) to illustrate performance differences in various geographic locations of the United States. See Figure 1 for a map of the ecoregions.

Table 9. Average per Year, Sum of Motor Box, Clutch and Sensor Failures per Site By Ecoregion Division For NADP Sites Operating July 1978 - March 1983. Values are normalized for years of operation.

Ecoregion Division	Approximate Location	No. of Sites	Sum of Failures per Site per Year Average	Range	Median
2100	Northeast/ Great Lakes	24	1.1	0-3.1	0.9
2200	Midwestern Forests	18	.5	0-1.3	0.4
2300	Piedmont/South	13†	.5	0-0.9	0.2
2500	Prairies	9	.3	0-0.9	0.2
3100	Great Plains	7	.4	0-1.1	0.5
	Mountains	18‡	.7	0-1.8	0.7

† excludes one site with a failure rate of 2.4

‡ excludes one site with a failure rate of 13.3

Overall the replacement rate was 5% (750 failures per 15000 samples) during the period July 1978 through March 1983. Collector component failure rates were greatest in the Northeast and Great Lakes regions followed by the Mountain regions. The Great Plains and Prairie states had the lowest failure rates. Although no seasonal stratification of the failure data was made, if both catch efficiency and failure rates are related to winter collector operation, as was suggested by Galloway and Likens (8), then the low failure rates in the Great Plains and Prairie states might simply be due to the milder winter conditions in these areas. Under this hypothesis, southern states would have the lowest failure rates compared with more northern and mountainous domains. Most likely, the seasonal and regional performance of the collector is a function of several meteorological variables (e.g. temperature, precipitation type, lightning, etc.), though the net result may be dominated by one factor or another in any particular region.

Of greater concern than the collector failure rates is the amount of 'down time' or periods of no sampling the failures create in the network data. Table 10 tabulates the average 'down time' by ecoregion, on a per site basis, using the average number of weeks any one site produces samples that are other than 'wet deposition only' samples (29) as the measure of down time. Generally, these are samples whose type of deposition (wet or dry) is undefined or mixed (e.g bulk samples). Since the vast majority of these types of samples are produced during periods of sampler malfunction, differences between Tables 9 and 10 largely reflect the 'down time' that each site experienced when a collector component failed. For example, in Table 9, sites in the Northeast/Great Lakes domains experience on the average 1.1 component failures per year. In Table 10 the number of weeks lost due primarily to collector failures in the region was 4.1. Comparing the two tables indicates that on the average for each component failure, ~4 weeks of data were lost (1.1 × 4.1). This is less than the 13 week per year average (all of which occurred in the winter) that can be calculated from Galloway's (8) data and more than the 0.6 per month average that can be calculated from Volchok's (33) data. Other regions in the NADP/NTN network vary from 4 (Northeast/Great Lakes and Mountains) to 12 (Great Plains) weeks of lost data for each component failure. Median down time in the network was 1 week, with individual instances ranged from 1-15 weeks.

Several factors interact to dictate the extent of down time during any one component failure. These include the effectiveness of site personnel and CAL in identifying component failures, the uncertainty on the part of site personnel as to how to order replacement parts -both procedurally and financially, and, the time period required to secure the correct replacement component. Though the emphasis in the preceding paragraph is on network and regional averaging, the importance of component failures and down time on individual site data sets cannot be ignored. Certainly one network week per year does not sound like a large percentage of the data; however, it should be noted that component failures coupled with long replacement part delivery times can in fact cause whole stations to be excluded from annual data summaries (16).

Table 10. Average Down Time per Site per Year by Ecoregion Division
February 1982 through December 1983 Using Undefined Sample Types

			Average per Site		
Ecoregion Division	Approximate Location	No. of Sites	Weeks of Down Time	Weeks of Operation	Down Time per Site per Year
	Means:				
2100	Northeast/ Great Lakes	28	12.5	175.6	4.1
2200	Midwestern Forests	32	6.62	138.3	3.1
2300	Piedmont/South	26	2.88	122.5	2.4
2500	Prairies	19	2.05	114.0	3.6
3100	Great Plains	17	5.11	91.6	2.6
	Mountains	24	6.29	137.4	2.8
	Medians:				
2100	Northeast/ Great Lakes	28	6.0	186.0	1.7
2200	Midwestern Forests	32	1.5	120.5	0.9
2300	Piedmont/South	26	0	81.5	0
2500	Prairies	19	1.00	77.0	0.7
3100	Great Plains	17	0	113.0	0
	Mountains	24	3.5	171.5	1.3

During the period of this report, site personnel were educated about abnormal collector operation through the formal operator training course offered at CAL, and, through telephone follow up with those sites indicating collector malfunctions via their weekly Field Observer Report Form. Part replacements were primarily a matter between each site and the manufacturer. Late in 1983, the network began increasing its efforts towards reducing the collector component failure down time rates. Detection of component failures by site operators and CAL was targeted with the development of an Aerochem Metrics Precipitation Collector Maintenance Manual (7). More recent efforts have focused on an improved delivery of Aerochem Metrics replacement parts through the implementation of a centralized NADP/NTN replacement part inventory and repair protocol. Both of these efforts should help the network in reducing the down time rate to the theoretical rate indicated in Table 9 -the failure rate plus one week.

SAMPLE INTEGRITY

The preservation of sample integrity from the time of entrapment at the field site, through laboratory analysis depends upon both the sampling protocol (i.e. event, daily, weekly) as well as the collector. The following discussion will be limited to two approaches that have previously been used to evaluate collector performance. The first measures the chemical degradation of rain water in the bucket from the time of precipitation to the time of analysis. The second measures the sealing properties of the collector lid over the bucket. Intrusion of non-desired species during the time the sample is protected from dry deposition and/ or evaporation losses are indicators of the effectiveness of the lid seal.

Galloway and Likens (8) and Peden and Skowron (20) have both addressed the stability of chemical species in the polyethylene buckets used with the Aerochem collector. Galloway and Likens (8) demonstrated the superiority of plastic to other surface materials and pointed out the variability introduced when different manufactures and grades of plastic are used. Peden and Skowron (20) demonstrated the stability (instability) of samples over time when the samples are kept in their original container. Both papers acknowledge that dry deposition rather than sample container construction is the predominate source of variability within wet only plastic bucket collectors.

The effectiveness of the lid seal has been evaluated by Stensland and Bowersox (28) and Stensland, Peden and Bowersox (29). NADP samples from sampling intervals when no precipitation occurred and where it could be confirmed that the collector did not open during the sampling interval were analyzed. Since these buckets had been cleaned, shipped, placed on the collector, sealed, returned to CAL and analyzed in the routine matter, they represent a system blank. These samples which are coded with a labtype of 'DA' are routinely produced and represent approximately 10% of the samples analyzed by NADP. The exact number produced at each station varies by region and is presented along with other sample type information in appendix B, part II.

Table 11 shows the number and average of DA values in micrograms/bucket by ecoregion divisions for all samples that were produced during the mid 1981-1983 period. Data prior to this time period are not available, except as summarized data in the March 1982, Stensland and Bowersox Draft Report (28), due to an error in a data transfer step between CAL and the Coordinator's Office. Though the error was fixed in late 1985, DA data prior to mid 1981 did not become available in time for this report. Like wet deposition samples, samples that have been confirmed to be contaminated or that were produced in a nonstandard manner have been excluded from the summary. The micrograms/bucket is calculated by multiplying the mg/L concentration of the DA sample times 50ml, the standard volume used in the NADP/NTN laboratory procedures to 'extract' the ion species from DA samples.

As with the other measures of collector performance, system blanks and therefore lid seal effectiveness, varies by region. Generally, lowest values are found in the western coastal areas while highest values are associated with open areas where blowing dust is likely. Calcium, sodium and magnesium, for instance, tend to be high in the Prairie states (2500's) where wind blown entrained soil is common. Whether the values in Table 11 indicate that the lid seal is not effective in preventing ambient gases or aerosols from entering the bucket directly or indirectly through adsorption on entrained soil, is not known.

Fortunately, uncertainties created by the regional differences in system bucket blanks are generally insignificant. Ratios of median DA values to median wet deposition samples reported by Stensland et al. (29) were typically less than 8%. Lid seal leakage can become an important bias, however, if it represents more than 10% of the deposition measured in a weekly sample. This is most likely to occur in samples from regions where precipitation and ion concentrations tend to be low. A more detailed summary of DA concentration data, by site, is presented in appendix C.

Table 11. Mean Dry Wet-Side (DA) Sample Blank Values by Ecoregion Division

Ecoregion Divisions	Approximate Location	No. of values	Ca	Mg	K	Na	NH4	NO3	Cl	SO4
			μ g/Bucket							
2100	Northeast/Great Lakes	84	4.1	1.0	1.7	6.8	3.2	6.5	6.0	19.8
2200	Midwestern Forests	98	13.2	1.2	2.1	9.2	3.3	10.0	6.2	18.4
2300	Piedmont/South	109	9.6	1.4	2.8	7.2	4.1	7.9	8.8	21.1
2410	Pacific Northwest	14	2.7	0.6	0.6	2.6	2.2	4.4	5.0	10.4
2500	Prairies	97	12.2	2.5	3.4	9.6	6.0	10.0	12.0	18.6
2610	California Valleys	46	3.0	1.3	2.8	3.4	2.7	4.2	5.2	9.0
3100	Great Plains	191	5.6	1.0	1.8	5.4	2.8	4.6	6.2	18.6
3200	Deserts	88	6.4	1.1	1.4	4.1	3.6	5.0	5.7	25.9
M3100	Rocky Mountains	78	5.7	1.0	2.3	12.0	3.1	6.2	7.0	19.8
M2000	Bitterroot/Cascades/ Coastal/Sierra Mountains	179	6.0	1.2	1.6	4.8	2.5	5.8	12.0	15.4

PRECISION

Collocated sampling is presently the only recognized method of determining the precision of precipitation chemistry collection devices. The NADP program has performed only one collocation study. The data from this study is available in the standard data set and is identified as the Finley Farm, NC a and b sites. The 'b' site was operated from October 1978 through April 1980. Other paired sites exist in the NADP data set however, the distance between the pairs are much greater than the 30 meters which defines an NADP site. Because of this greater separation these pairs are better suited to the study of regional and local representativeness.

Table 12 presents precisions estimates of the Aerochem Metrics Wet/ Dry collector using three different equations. Each calculation has been reported in previous studies as a useful method of estimating collector precision at a single site. For comparison purposes, precision estimates for the collector pair operated at the Finley Farm, by NADP during 1981, have been calculated using each of the methods. Each set of estimates is identified by Author and then by data source. The number of collector pairs and the separation between the pairs is also given. Equations for each method are given immediately following the table. It should be noted that precision estimates are not normalized for distributional differences in precipitation amounts or concentration between the various data sets.

In spite of the differences in values all calculations indicate that there are big differences in precision among the elements. The worst precisions found by both Bogen (5) and Topol (30) are with Potassium, Sodium, Calcium and Chloride. NADP's estimates are similar except Ammonium replaces Calcium in the NADP list. Differences in NADP data vs other investigators is most likely due to the differences in sampling protocols. The daily (Topol) and event (de Pena) samples are stabilized much sooner than the weekly NADP samples. This is most apparent in the case of ammonium. Differences between the UAPSP data and NADP may also be due to the number of sites involved in the UAPSP figures. These figures represent a pooled site statistic while the NADP values are from a single site. NADP does not know for instance if the Finley Farm Site comparison is representative of a pooled network statistic.

Additionally, as would be expected, comparison of the highly averaged values used in the traditional calculation (a comparison of the two averages from each individual sampler) yields a tighter precision estimate than the comparison which uses many individual pairs of data to determine precision estimates. This implies that precision estimates of annual or seasonal averages will be less than those of individual sample intervals.

Table 12. Precision Estimates of the Aerochem Wet/ Dry Collector

Author/ (Reference)	Ca	Mg	Na	K	NH4	NO3	SO4	Cl	pH	Cond	SVOL
						Percent (%)					
Topol (80)	UAPSP Daily Samples, collectors 1.5m apart										
(900 pairs)	16.4	11.4	24.9	41.9	8.0	5.1	5.0	12.1	1.42	3.6	4.9
(96 pairs)	14.7	9.2	7.3	22.3	7.4	3.5	3.8	6.2	0.45	5.0	2.3
(53 pairs)	8.6	9.3	18.4	20.6	4.4	2.6	3.2	14.7	1.81	5.8	4.6
de Pena (21)	Penn State University 42 - 61 Events, collectors < 50m apart										
3 collectors					16.7	10.9	7.2			5.8	4.0
Traditional	*Bogen data (5)*; Sum of Mass in 24 Monthly Samples, collectors 3m apart										
(1 pair)	1.3	0	0.2	1.9			0.4	0.6	0.09	0	0.1
NADP comparison of Finley a and b: weekly samples, collectors ~30m apart											
Using *Topol's* Calculations:											
(54 pairs)	12.5	13.3	42.6	27.5	31.1	12.5	12.3	21.9	1.5	13.8	3.2
Using *de Pena's* Calculations:											
(54 pairs)	26.5	22.3	62.6	36.8	42.0	19.8	26.0	35.8	3.27	19.7	8.3
Using *Traditional* Calculations:											
(1 pair)	2.4	0.9	6.7	1.3	3.5	1.8	2.8	2.1	0.004	1.7	0.1

Topol calculations:

Relative Precision (RP) = Median of Absolute Collocated Differences (ACD) / Median of Collocated Values.

$$\textit{Relative Precision} = \frac{\textit{median}\left|X_i - Y_i\right|}{\textit{median}\left(X,Y\right),} \tag{1}$$

$$\textit{Average Error} = \textit{median}\sqrt{\frac{ACD}{2}} \tag{2}$$

de Pena calculations:

Precision = Percent Mean Deviation (MD)

$$d = \frac{\sum_{i=1}^{i} \left| X_i - \overline{X_i} \right|}{m} \tag{3}$$

$$Percent\ Mean\ Deviation = \frac{100}{n} \sum_{i=1}^{i} \left[\frac{d}{\overline{X_i}} \right] \tag{4}$$

where m is the number of collectors, n is the number of events.

Traditional Calculation:

Precision = Pooled Standard Deviation (PSD) / Mean (X + Y)/2

$$ASE = \sqrt{\frac{\sum_{i=1}^{i} \left(X_i - Y_i \right)^2}{2n - 1}} \tag{5}$$

$$PSE = 100 * ASE \tag{6}$$

where n is the number of pairs.

Rain Gage Performance

Within the NADP program, performance of the of the Belfort weighing, recording, rain gage has been assessed by site performance tests (sand bottle tests) and by a one time audit of rain gage performance made during site visits conducted by the United States Military Academy. The sand bottle performance test, a simple check sites can perform themselves, was developed by the Central Analytical Laboratory when it was confirmed that most sites did not keep calibrated rain gage weights on hand, and, that it would be impractical to ship them to each network site. During site visits, a set of calibrated rain gage weights were used to test rain gage calibration at one inch rain equivalent intervals up to the full range of gage capacity. If adjustments were deemed necessary, they were made. Results of the sand bottle tests were tabulated quantitatively while site visit results were recorded qualitatively.

SAND BOTTLE TESTS

In October of 1981 NADP sites were sent two 250ml plastic bottles filled with sand, each representing approximately 0.55 inches of rain when added to the Belfort rain gage. The sites were asked to add the bottles, one at a time to the gage, marking the displacement it made on a test rain gage chart. A final check called for loading the gage so that the pen traced past the rain gage turnover point (6.00"), the theoretical midpoint of pen's full scale traverse. The charts were then sent to CAL for evaluation. The test was repeated in September of 1983. Prior to these tests, rain gage preformance was not evaluated on a network basis.

Table 13 gives results of the two sand bottle rain gage performance tests. Sixty-one of 75 sites (81%) in 1981 and 112 of 130 (86%) of the NADP sites in 1983 participated in the tests. For both years, more than two thirds of the sites performed within the theoretical chart reading errors of ± 4.0% on both bottles. Two sigma for both bottles in both years was < ± 11% meaning that 90% of the sites had errors of less than ± 0.05 inches out of the 1.1 inch total tested. For both bottles in both years, the percent errors were negative indicating that the rain gage measured less than the expected sand bottle rainfall equivalents. Errors were worse for bottle one than bottle 2 in both years though not significantly. Turnover points also tended to be lower than the expected 6.00 inches. Turnover point performance was within one standard deviation at 84% of the sites in 1981 and at 90% of the sites in 1983.

Table 13. Two σ Error Results for Rain Gage Sand Bottle and Turn Over Performance Tests

Test	Two σ Error by Year 1981	 1983
Bottle 1 (0.55")	8.1 %	7.7 %
Bottle 2 (1.10")	10.6 %	9.1 %
Turnover (6.00")	0.23"	0.35"

Similar results, though not quantitative, were found by Robertson et al (24) during site visitations. Their tallies show that of the rain gages that were checked, 82% had acceptable calibration and did not require adjustment. Only 54%, however, had acceptable turnover point calibration. (see appendix A). That the turnover point performance figure is so low, is not surprising since the turnover point adjustment is a very easy one to make. During the West Point visitations these adjustments were made routinely to gages needing only slight adjustment (< 0.05 inches).

COMPARISON TO NATIONAL WEATHER SERVICE STATIONS

The catch efficiency maps in Figures 2 and 3 indicate that winter catch is poor in the ecoregions of the Great Plains, Prairies and Great Lakes. Poor catch can be due to overcatch by the rain gage or undercatch by the collector. However, the scientific literature (9, 18, 34) indicates that, if anything, the Belfort rain gage is prone to undercatch not overcatch. On the other hand, if catch efficiency is good and the collector is known to be poor then the rain gage may be undercatching precipitation in proportion to the collector. This case is important from the network point of view if the undercatch is disproportionately lower than 'standard' values. The relevance of the National Weather Service (NWS) values to 'true' precipitation is beyond the scope of this report. However, if we accept NWS values as our standard, then rain gage performance may be evaluated by comparing the rain amounts recorded by the NADP site operators with those of nearby gages run by the National Weather Service (17).

Twenty-four NADP sites and 25 NWS stations were found that met the criteria listed below. The comparison stations are listed in Table 14. No attempt was made to normalize the difference in reporting periods between the two programs. The number of days summarized in the NADP annual sums do not correspond to NWS calendar year totals, however, the differences are assumed to impact the comparison minimally since the maximum difference should be only 7 days (~1.5%) and they occur during traditional times of low precipitation.

Criteria Used:

1) NADP and NWS stations had to be within 10km of each other.
2) The NWS and NADP stations had to have had a concurrent and continuous three year precipitation record.
3) The NWS observer and the NADP site operator were not the same person.
4) The NADP station had a precipitation coverage rating of more than 90% (see Appendix B).

The median difference between NADP and NWS stations, measured as the relative mean standard error (RMSE) was 5.8% over all three years. Annual RMSE's ranged from 7.4% in 1982 to 8.4% in 1983. Median differences ranged from a high of -5.00 cm in 1981 to a 1983 low of -1.89 cm. No ecoregion or separation (distance or elevation) effects were noted even though some stations were separated by as much as 8km and approximately 200m in elevation. Like the sand bottle tests this comparison demonstrated a negative bias (two σ RMSE = 12%) in the NADP precipitation values. The bias is however, well within the 4%- 25% error ranges reported by other investigators for annual precipitation values with similar station densities (10, 22, 31).

Table 14. List of NADP vs NWS Stations Meeting Comparison Criteria

				Separation	
State	NADP station	NWS Station	Ecoregion	distance	elevation
AK	Denali (McKinley) National Park	McKinley Park	M1310	1.4 km	- 18 m
AZ	Organ Pipe Cactus National Monument	Organ Pipe NM	3222	2.5 km	- 5 m
AR	Fayetteville	Fayetteville Exp. Sta.	2215	0.01 km	4 m
CO	Rocky Mountain National Park	Estes Park	M3113	6.8 km	196 m
IL	Dixon Springs Agriculture Center	Dixon Springs Agr. Ctr.	2215	0.6 km	- 4 m
ME	Greenville Station	Harris Station	2114	3.1 km	69 m
MI	Douglas Lake	Pellston	2113	0.6 km	55 m
MI	Kellogg Biological Station	Gull Lake Bio Sta.	2212	1.1 km	17 m
MN	Lamberton	Lamberton SW Exp. Sta.	2531	1.2 km	- 6 m
MT	Glacier Fire Weather	West Glacier	M2112	1.1 km	7 m
NE	Mead	Mead Agronomy Lab	2531	8.2 km	- 8 m
NC	Lewiston	Lewiston	2320	0.6 km	11 m
NC	Coweeta	Coweeta Exp. Sta.	2214	0.7 km	1 m
NC	Clinton Crops Research Station	Clinton 2NW	2320	0.9 km	- 1 m
NC	Finley (a)	Raleigh NC State Univ.	2320	6.1 km	- 3 m
OH	Delaware	Delaware	2212	8.0 km	23 m
OH	Delaware	Delaware Dam	2212	1.3 km	2 m
OH	Wooster	Wooster Exp. Sta.	2212	1.2 km	4 m
OR	Lost Creek Dam	Lost Creek Dam	M2415	0.1 km	- 6 m
SC	Clemson	Clemson University	2320	2.3 km	- 29 m
TN	Walker Branch Watershed	Oak Ridge ATDL	2214	6.2 km	65 m
TX	K-Bar	Panther Junction	3212	2.8 km	- 84 m
VA	Horton's Station	Mt. Lake Biological Sta.	2214	6.0 km	-129 m
WV	Parsons	Parsons 1 SE	2214	1.1 km	-207 m
WI	Spooner	Spooner Exp. Farm	2111	0.7 km	- 4 m

General Site Performance

The NADP Instruction Manual for Site Operation (13) specifies the procedures that each site operator is to follow each week on Tuesday at 9:00 am. Of paramount importance is the completion of the weekly Field Observer Report Form (13). This standard form is the primary means of communication between the site and the Central Analytical Laboratory. It is also represents the primary documentation of site activities for the weekly sampling intervals. In the fall of 1980 a series of note and error messages was developed by CAL to accompany a computer-generated preliminary report of field form information that was being routinely passed back to the site operators and site supervisors for their verification. The messages were developed to alert sites to gross errors that might have inadvertently been reported to the Central Laboratory via the Field Observer Report Form. These note and error messages are listed in Table 15.

Table 15. Explanation of Note and Error Messages Generated by CAL's Computer Evaluation of Field Observer Report Forms.

Error or Note	KEY
Error 1.	Time on for sample _______ precedes the time off for sample _______. Please notify CAL of the correct times by sending a note with your next bucket mailing.
Note 2.	Time between sample _______ off and sample _______ on is greater than 3 hours (# of hours given). Possible missing samples.
Note 3.	The sample interval for _______ was nonstandard. The interval was _______ days.
Note 4.	_______ did not have a standard Tue-Tue sampling period. Actual sampling period was Mon-Mon (or the like; for general).
Note 5.	The field pH for sample _______ (pH) was outside the expected range for precipitation samples. (Expected range is _______ to _______.)
Note 6.	The lab pH differed by more than 1. pH unit from the field pH for sample _______.
Note 7.	Conductance <1 or > 300.
Note 8.	The lab conductivity differed by more than 20 μ mho from the field conductivity for sample _______.
Note 9.	The liquid depth of sample _______ does not compare well with the precipitation depth recorded for that period. Please re-check your rain gage chart and event record to confirm the precipitation depth and the proper operation of the collector. Notify CAL of any changes.
Note 10.	Sample _______ had major leakage during shipment to CAL.
Note 11.	A required date or time for sample _______ is missing. Please notify CAL of missing information by sending a note with your next bucket.
Note 12.	Sample _______ was not bagged. Please bag all buckets before shipment to CAL.

Table 16 lists the percent of irreconcilable messages remaining in the Network by year for each message type. These messages appear on the CAL field printouts and represent only those messages remaining after CAL and the sites have tried to resolve the nature of the message. This percent is used in lieu of the percent occurrence of each type of message. The percent occurrence information is not routinely summarized. Though the table does not indicate the number of messages that were resolved by the Central Analytical Laboratory (CAL) it does demonstrate that progress is being made in eliminating some categories of field problems. Error types 1 and 11 as well as Notes 5 and 7 are for instance, being resolved by CAL. We don't know how often these messages occur, however we do know that the problem they represent is being eliminated from the list of site problems prior to the site data entering the data archive. Other messages such as Notes 6, 8, and 9 show continuing progress in reducing the occurrence of these class of problems in the data archive. We can only assume that the numbers also reflect a reduced number of occurrences at CAL. The table also points to areas were progress has been somewhat difficult to achieve. Notes 2, 3, 6 and 9 are areas that show some progress but continue to remain at levels somewhat greater than our established goals for the Network.

Table 16. Percent of Irreconcilable CAL Generated Site Messages By Year and Type

	Percent (%)											
Year	ERROR 1	NOTE 2	NOTE 3	NOTE 4	NOTE 5	NOTE 6	NOTE 7	NOTE 8	NOTE 9	NOTE 10	ERROR 11	NOTE 12
1978	0	8.8	4.4	0	0	8.4	3.2	7.2	13.6	†	0.8	†
1979	0.3	4.2	7.6	0.3	0.1	7.8	0.1	3.2	14.9	1.4	0.5	29.8
1980	0	7.4	8.1	1.4	0	5.6	0.2	2.9	9.2	5.7	0	12.0
1981	0.1	7.9	5.2	0.4	0	5.7	0.1	2.2	7.4	2.3	0	4.2
1982	0	7.1	4.7	0.1	0	3.9	0.1	2.0	9.0	2.8	0	1.8
1983	~0	0.4	4.8	~0	~0	4.4	0.1	3.1	10.5	3.3	0	0.6

† The bagging of NADP buckets, which is the major source of information concerning sample leakage during shipment was not being routinely monitored during the initial months of the program.

A more general estimate of site performance which groups the CAL Note and Error messages by problem area is described in Table 17 (4).

Table 17. Performance Evaluation Groupings for CAL Note and Error Messages

Group Number	Key
I	A combination of notes/errors 1, 2, 10, 11, 12, which are all considered carelessness
II	A combination of notes 3 and 4, both having to do with nonstandard sampling periods or not followed protocols.
III	A combination of notes 5 and 6, both having to do with pH, either not in expected pH range or a difference of one unit or more.
IV	Note 8. Large differences between Laboratory and Field Conductivity Measurements.
V	Note 9. Large Differences between the Wet/ Dry Collector and Rain Gage Volumes.

Table 18 presents a tally of this grouping. Not surprising is the fact that the table shows that site operators and CAL have continued to work together to reduce the number of carelessness, sampling protocol, pH, conductivity and catch efficiency problems in the network. The initiation of a site operator training program, the development of pH check samples for site operators, the improvement in the Instruction Manual for Site Operations and the development of the Note and Error message feedback system all contributed to the improvement.

Table 18. Grouped Note and Error Messages

	No. of	Percent (%)				
Year	Sites	I	II	III	IV	V
1978	22	--	2.2	4.2	7.2	13.6
1979	37	9.1	3.9	3.9	3.2	14.9
1980	82	5.0	4.7	2.9	2.9	9.2
1981	99	2.9	2.8	2.8	2.2	7.4
1982	113	2.3	2.4	2.0	2.0	9.0
1983	149	0.9	2.4	2.2	3.1	10.5

Another estimator of overall site performance can be obtained by tallying the excluded and less than perfect data by record Type and Notes codes classifications. The Type and Notes codes are used in NADP data reports and data tapes to summarize comments and remarks associated with weekly NADP data. The codes are translated from Field Observer Report Form data, CAL and Coordinator Office comments and data quality checks. Table 19 presents annual tallies for the 1978-1983 data. The key to the various type and notes codes are listed below .

Missing Records summarize various categories of data completeness.

SR	Site Records. Number of records reported by the site for this summary period.
PR	Precipitation Records. Number of records which have precipitation information.
BS	Bucket Substitutions. Samples whose only valid precipitation measurements come from the Wet/ Dry collector bucket.
NN	No Information. Information was never reported and will never be available for this collection period.

Problem Record codes are a summary of remarks written about a weekly sample by field personnel, the Central Analytical Laboratory (CAL) or the NADP Coordinator's Office.

NS	No Sample. No chemistry data will be reported for this sample. These data have been excluded from the report for various reasons, including extreme contamination, lack of conforming to a definable sample type, leakage, or loss in the mail.
BU	Bulk Sample. A wet side sample that was continuously exposed to both wet and dry fall during the sampling period.
SP	Sample Protocol Problem. Sample does not meet NADP sampling protocol requirements. The sample probably characterizes the individual site adequately but is not suitable for across-site comparisons. Examples of this problem include nonapproved sampling sites, nonapproved sampling equipment, and nonapproved or irregular sampling intervals.
LD	Long Duration Sample. LD indicates any sample left on the collector for multiple sampling periods.
TL8	Time Limit. The sampling interval exceeds eight days.
TL13	Time Limit. The sampling interval exceeds thirteen days.

Lab Type indicates the condition of the sample as it arrived at the Central Analytical Laboratory (CAL).

W	indicates a normal sample.
WA	indicates the sample had to be diluted for analysis; 50 ml of water was added.
T	indicates a trace; dilution was unwarranted.
DA	indicates the bucket arrived dry.
QA	indicates this sample was a Quality Assurance Sample.

Table 19. Record Type and NADP NOTES code Summary by Year.

	Missing Records				Problem Records						Lab Types				
YEAR	SR	PR†	BS†	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
1978	83.6	73.6	32.7	13.8	2.5	0.3	0.3	3.1	3.1	3.1	67.2	2.0	4.3	8.6	0
1979	95.2	84.1	21.6	3.8	3.1	2.3	0.7	1.0	1.5	1.0	75.1	2.8	6.4	7.8	0.2
1980	95.4	79.2	27.1	3.2	7.3	2.1	2.7	1.4	2.0	1.5	66.5	3.6	6.5	12.6	0.5
1981	96.6	94.9	12.7	2.4	10.8	1.4	7.3	1.0	1.3	1.1	72.4	4.0	7.5	12.0	0.8
1982	97.3	96.9	11.7	1.5	10.6	1.9	5.9	1.2	1.6	1.2	77.4	4.1	6.9	9.6	0.4
1983	98.2	97.4	10.4	0.7	8.2	2.5	8.1	1.2	1.5	1.2	77.7	3.5	7.6	10.1	0.4

† computed as a percent of SR (site records)

Typically, more than 90% of all Network data meets the high standards set by the NADP program. The table repeats some of the information presented in Tables 6 and 7, the annual summary criteria (PR, BS, NN) and details other parts (Valid Samples) by breaking down the criteria into some of their key components. Problem records, for instance indicate that the dominant reason for invalid samples is due to extreme contamination or lack of a definable sample type, i.e. it could not be determined if samples were wet deposition only samples. In 1981 and 1982 a 2% increase in this record type was observed in the network. Whether this is due to new operator problems or better detection by program staff is not known, although it should be noted that CAL did assign a person full time to screen data for these problems beginning in 1980. Bulk samples (BU) have remained at ~2% while expanded sampling intervals (LD, TL8, TL13) seem to occur in about 1.5% of network samples.

From previous discussions, we know that CAL has initiated many programs that have improved operator competency, detection of sample anomalies and sample protocol violations. We also have shown that sampling protocol violations and missing records are an insignificant part of the valid sample problem. Operators are for the most part doing an excellent job of following network procedures. The Record Type Summary is presented by site in appendix B II.

Documentation

Traditionally, documentation of site activities, as well as most other activities of the NADP program, has been the responsibility of each program contributor. This is especially true of quality assurance activities and includes standard operating procedures (SOP's). With the exception of reports of weekly precipitation chemistry, reporting of SOP's and quality assurance data has been done in the context of scientific journal articles, meeting proceedings, agency reports and the like. Until recently, no attempt had been made to consolidate this information into a network document. The documents discussed below are still the only formal documents which address the time period of this summary. Fortunately, they also still represent current practice.

SITE SELECTION

Site selection criteria was first outlined in The Plan for Research For NC-141 North Central Regional Project On Atmospheric Deposition (6). The first siting manual (27) was published in March 1978. Slight revisions were made in September 1979 and the manual was reissued under the new National Atmospheric Deposition Program name. The newest siting manual (14) further explains and clarifies the siting criteria that has always been used by the NADP when approving sites or determining their regional representativeness.

SITE DESCRIPTIONS

The original Site Description Questionnaire (appendix D I) was developed in conjunction with the first site selection manual (27). In 1981 a supplement to the questionnaire (appendix D II) was developed by subcommittee 1 (Site Selection and Certification) of the NADP Technical Committee. Each site was asked to complete the supplement as a part of a site documentation review by the subcommittee. Between 1981 and 1983 the questionnaire was revised continuously to better accommodate the information being submitted by the various people installing new sites. The present Site Description Questionnaire was completed in early 1984.

Because the information on the site descriptions was often initially incomplete, was arriving at the Coordinator's Office on a variety of forms and was constantly being updated through communications with the site, CAL and site visitation reports, a computerized text version of the questionnaire was installed at the Coordinator's Office. These files comprise the primary documentation of each of the operating sites. Appendix D III gives an example of one such site description.

Work is currently under way to convert these text files into a database so that scientists can use the site documentation information to select subsets of the chemistry data for analysis. A one-time, updatable NADP Site Description publication is also being produced. This publication will contain a portion of the data base attributes as well as a map and picture of each site.

SITE OPERATION

The weekly sampling protocol for the NADP network was also first detailed in The Plan For Research (6). A Field Observer Instruction Manual (26) published in May 1978 was updated in 1982 (13). The 1982 manual is the current manual and like the current site selection manual, further explains site operating protocols that have not changed since the network was initiated.

SITE QUALITY ASSURANCE

Quality Assurance procedures for site operations were discussed in a 1983 paper titled *NADP Quality Control Procedures for Wet Deposition Sample Collection and Field Measurements* (29). Prior to this publication no formal documentation of NADP site quality assurance procedures was available.

Summary and Recommendations

GOALS

The NADP Quality Assurance Plan for Deposition Monitoring (15) established seven goals that it hoped to achieve with its site operations. The goals are listed below.

Goal 1 Sample 100% of the weeks when there was wet deposition at each site

Goal 2 100% of the data reported correctly on the Field Observer Report Form

Goal 3 Field pH accuracy for pH > 5.0 should be ± 0.3 pH and for pH < 5.0, ± 0.1 pH

Goal 4 Field conductivity accuracy should be ± 4 μ mhos

Goal 5 Accuracy of sample weights should be ± 1g

Goal 6 Wet/ Dry collector catch efficiency should be 90-110%

Goal 7 Rain gage accuracy should be ± 0.05 inchs

The collection of samples from 100% of the weeks when there was wet deposition, goal 1, has not been met during the summary period of this report. However, steady network improvement has been shown (Table 6). On an annual basis the number of network weeks that were unaccounted for dropped from ~14% to less than 1%. Precipitation accountability has increased from ~74% to 97% and the number of valid samples produced has increased on the average from 21% to 68%. However, if additional progress is to be made in producing more valid network data, then, the amount of collector 'down time' must be reduced. This along with the continued improvement of the operation of the collector appear to be the only two areas that have not demonstrated considerable progress in the program. A centralized spare parts inventory and increased competency in detecting and repairing collector malfunctions should help increase the number of valid samples.

The incidence of correct information on data forms, goal 2, has also shown steady progress (Table 19) increasing from 73% in 1978 to 98% in 1983. In both of these cases increased staffing and operator training programs at CAL as well as the publication and clarification of measurement criteria (13,14) has resulted in an increasingly more complete data set. The level of activity necessary to continue the programs started should continue in the hopes that we will achieve the NADP goal of 100% completeness in our field data collection.

Wet/ Dry collector catch efficiencies have remained relatively constant during the five years summarized, and, on a network basis, is just at or above the network goal of 90-110% (goal 6). Since, as pointed out in Figures 2 and 3, poor catch is a seasonal phenomenon in selected regions, the network may not see improvement without considering another type of collector better suited to the extreme conditions of the affected regions. One could argue however, that the network has achieved its goal in this area and the introduction of another collector at this time is not necessary. The variation in the network average is probably due to the addition of new sites in these extreme areas followed by the addition of sites in non-extreme areas. Criteria upon which to evaluate another type of collector has been given in tables 9-12.

Another way of improving the catch efficiency statistic might be to give more frequent (i.e. daily) attention to the sampling equipment in those areas displaying poor catch. The increased attention might improve the detection of faulty or marginally operating equipment during times of extreme cold, snow and wind.

Rain gage accuracy (goal 7) has been the most neglected part of the NADP field operations. Only two performance audits were made during this summary period. Though the results of the two sand bottle tests indicate that 90% of the sites were meeting the network accuracy goal of ±0.05 inches there is insufficient information within the network to determine if NADP rain estimates are within tolerable levels. The sand bottle tests should be reinstituted immediately and performed at each site at least once per year.

The other three goals listed in the Quality Assurance Plan (15) are concerned with field laboratory measurements. These goals will be discussed in the quality assurance reports on laboratory operations.

ERROR ESTIMATES

There are three principle components of Network operations that define the limits of uncertainty in a network's precipitation chemistry estimates. These are: 1) the uncertainties created by the sampling methods, instrumentation and protocol used to make the measurements, 2) the uncertainties created by the level of representativeness and completeness of the measurements and, 3) the uncertainties associated with the stratification and use of the data. In the NADP network these components are further broken down into the three areas of network operations. These are the field operations, the laboratory operations, and data management. Since the uncertainty associated with each component is additive, ideally, only one component per operational area at a time would be addressed by a particular quality assurance activity. In practice the activities available to make such uncertainty estimates are rarely so convenient. Like programs operating within the NADP network (Table 1), most estimates include a pooled variance which incorporates more than one principle component category and more than one operational area. When combining the activity error estimates to produce overall error estimates it is almost impossible to determine if the activity errors are additive, multiplicative, or something else. Additionally, it is often difficult to prevent some types of errors from being inadvertently applied more than once in the overall estimate. Some practical examples of producing uncertainty estimates in the CANSAP and CAPMoN networks are given by Vet and Onlock (32) and Barrie and Sirois (3).

Another approach to determining overall estimates of uncertainties is to try to measure *minor* components of Network operations and pool the variances associated with each minor component in an appropriate manner to determine the over all estimate of uncertainty. An an example of minor component summing would be to add catch efficiency uncertainties to precipitation coverage deficiencies and calcium measurement uncertainties to establish error bounds on calcium deposition for a given site in a given week. This approach suffers from the same overlapping error problems as previously described and from the lack of knowledge as to whether the minor component variances are additive or etc.?. Perhaps the biggest deterrent to this type of approach is the expense of identifying and developing a quality assurance activity that addresses each minor component of Network uncertainty. The magnitude of the problems associated with this approach are illustrated in the proceedings of an Advisory Workshop on Methods for Comparing Precipitation Chemistry Data (19). In this document a multitude of quality assurance activities are identified which would be useful for comparing network data and assigning estimates of uncertainties to data interpretations.

In the NADP network a combination of the two approaches can be used. For overall estimates, a quality assurance activity that encompasses as many minor components as practical establishes most of the estimate. Key minor component estimates are then made which can be added or subtracted from the preliminary estimate to compute the overall estimate. Field operation estimates, for instance, almost always contain both the field and laboratory estimates since the data produced is usually a chemical analysis value. As mentioned previously the correct calculation of these estimates depends, as with the definition of a region, entirely on the use to which the data will be put.

CONCLUSIONS

NADP field site operation appears to be good. However, the information available to make such assessments is difficult to assemble due to the many agencies involved in network quality assurance and the different schedules of data publication each keeps. Additionally, many of the agencies summarize quality assurance data to fit their agency needs. As pointed out, the data have many uses beyond the need of individual agencies that identify unique stratifications of network data. It would be very beneficial to the network if quality assurance data could follow the same schedule of reporting as the wet deposition chemical analysis data. This would make the quality assurance reporting smoother and have the additional benefit of providing NADP and NTN network planners with more timely feedback of network performance.

Programs developed by individual agencies, such as the sand bottle testing at CAL or the site visitation program conducted by the United States Military Academy and now by the Research Triangle Institute, need to be given the same priority as chemical analysis and maintained on a regular schedule to insure that a complete picture of network site quality is available.

Finally, audit programs, whether they be paper, field or performance audits, need to be coordinated so that conflicting results are correctly interpreted by the network and competing efforts are worked out of the system. This is the only way the network will be able to afford to get the quality assurance information it needs to evaluate its technical approach to operating a national atmospheric deposition network.

References

1. Bailey, R.G.. 1980. **Description of the Ecoregions of The United States**. Publication 1391. United States Department Of Agriculture.

2. Bailey, R.G. and C.T. Cushwa. 1981. **Ecoregions of North America After The Classifications Of J.M. Crowley**. Scale 1:12,000,000. United States Fish and Wildlife Service, Eastern Energy and Land Use Team, Kearneysville, West Virginia.

3. Barrie, L.A., and A. Sirois. 1982. **An Analysis and Assessment of Precipitation Chemistry Measurements Made by CANSAP (Canadian Network for Sampling Precipitation: 1977-1980**. Report AQRB-82-003-T, Atmospheric Dispersion Division, Air Quality and Inter-Environmental Research Branch, Atmospheric Environment Service, Downsview, Ontario.. pp 163. June 1982.

4. Binney, E., Baron, J. and D.S. Bigelow. 1982 **Evaluation of National Park Service Participation in the National Park Service I. An Overview** . Report No. 82-4, National Park Service, Water Resources Field Support Laboratory, Colorado State University, Ft. Collins, Colorado.

5. Bogen, D.C., Nagourney, S.J. and C. Torquato. 1980. **A Field Evaluation Of The HASL* Wet-Dry Deposition Collector**. Water, Air and Soil Pollut., Vol. 13, pp 453-458.

6. Cowling, E.B., Fulkerson, J., Huston, K. and J.H. Gibson. 1977. **Plan Of Research For NC-141 North Central Regional Project On Atmospheric Deposition: Chemical Changes In Atmospheric Deposition And Effects On Agricultural And Forested Land And Surface Waters In The United States**. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado. September 1982.

7. Dossett, S.. 1984. **Aerochem Metrics Precipitation Collector Maintenance Manual**. Contract Report to the National Atmospheric Deposition Program, SWS no. 348, Illinois State Water Survey, Champaign, Illinois. September 1984. p 28.

8. Galloway, J.N. and G.E. Likens. 1976. **Calibration of Collection Procedures for the Determination of Precipitation Chemistry**. Water, Air and Soil Pollut., Vol. 6, pp 241-258.

9. Goodison, B.E.. 1978. **Accuracy of Canadian Snow Gage Measurements**. Journal Of Applied Meteorology, Vol. 17, pp 1542-1548.

10. Granat, L.. 1975. **Principles in Network Design For Precipitation Chemistry Measurements**. Proceedings of the First Specialty Symposium on Atmospheric Contribution to the Chemistry of Lake Waters, International Association of Great Lakes Research, September 28 - Oct 1. pp 42-55.

11. A.A. Haasz. 1979. **Report on A Preliminary Study for Snow Collection Gauges**. Technology Development and Appraisal Branch, Ontario Ministry of the Environment, Air Resources Branch, Toronto, Ontario. March 30, 1979. also issued as University of Toronto Institute for Aerospace Studies, UTIAS Technical Note No. 219, Toronto, Ontario, May 1979.

12. Larson, L.W., and E.L. Peck. 1974. **Accuracy of Precipitation Measurements For Hydrologic Modeling.** Water Resources Research, Vol. 10, No. 4 pp 857-863.

13. National Atmospheric Deposition Program. 1982. **NADP Instruction Manual: Site Operations**. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado. January 1982.

14. National Atmospheric Deposition Program. 1984. **NADP Instruction Manual: Site Selection and Installation**. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado. July 1984.

15. National Atmospheric Deposition Program. 1984. **The NADP Quality Assurance Plan: Deposition Monitoring**. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado.

16. National Atmospheric Deposition Program. 1985. **NADP Annual Summary of Precipitation Chemistry For 1982**. Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado.

17. National Oceanic and Atmospheric Administration. 1981, 1982, 1983. **Climatological Data Annual Summary: "STATE"**. National Climatic Data Center, Asheville, North Carolina. various volumes, No. 13.

18. Neff, E.L.. 1977. **How Much Rain Does A Rain Gage Gage?**. Journal Of Hydrology, Vol. 35, pp 2132-220.

19. Pack, D.H. and A.A. Shepherd (ed). 1983. **Proceedings: Advisory Workshop on Methods for Comparing Precipitation Chemistry Data**: UAPSP-100. Rensselaerville, New York, August 10-12, 1982. Workshop Proceedings prepared by Sigma Research, INC, Richland, Washington. February 1983.

20. Peden, M.E. and L.M. Skowron. 1978. **Ionic Stability of Precipitation Samples**: Atmospheric Environment, Vol. 12, pp 2343-2349.

21. de Pena, R.G., Pena, J.A. and V.C. Bowersox. 1980. **Precipitation Study Intercomparison Report**. Dept. of Meteorology, Pennsylvania State University, University Park, Pennsylvania.

22. Phanartzis, C.A. and C.C. Kisiel, **Uncertainties in Point and Areal Sampling of Precipitation and Their Importance in Hydrological Computations**. International Symposium on Uncertainties in Hydrologic and Water Resource Systems, pp 341-357.

23. Robertson, J.K. and J.W. Wilson. 1985. **Design of the National Trends Network for Monitoring the Chemistry of Atmospheric Precipitation**. U.S. Geological Survey, Circular 964. U.S. Geological Survey, National Acid Precipitation Assessment Program. Alexandria, Virginia.

24. Robertson, J.K., Wilson, J.W. and R.C. Graham. Unpublished. **Site Visitation Reports**. United States Military Academy, West Point, New York.

25. Schroder, L.J., Linthurst, R.A., Ellson, J.E. and S.F. Vozzo. 1985. **Comparison of Daily and Weekly Precipitation Sampling Efficiencies Using Automatic Collectors**. Water, Air and Soil Pollut., No. 24, pp 177-187.

26. Semonin, R. and H.L. Volchok. 1978. **Field Observer Instruction Manual, North Central Regional Project NC-141:Atmospheric Deposition**. National Atmospheric Deposition Program, Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado. May 1978.

27. Semonin, R. and H.L. Volchok. 1979. **Site Selection and Certification, North Central Regional Project NC-141: Atmospheric Deposition**. National Atmospheric Deposition Program, Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, Colorado. March 1979.

28. Stensland, G.J. and V.C. Bowersox. 1982. **DRAFT REPORT: Evaluation of Dry Wet-Side NADP Samples**. Illinois State Water Survey, Champaign, Illinois. March 1982.

29. Stensland, G.J., Peden, M.E. and V.C. Bowersox. 1983. **NADP Quality Control Procedures for Wet Deposition Sample Collection and Field Measurements**. paper No. 83-32.2, 76th Annual APCA Meeting, Atlanta, Georgia. June 1983. pp 20.

30. Topol, L.E., Colovos, G., and R. Schwall. 1982. **Precision of Precipitation Chemistry Measurements**. Proceedings of Air Pollution Control Association Specialty Conference on Acid Precipitation, Detroit, Michigan. November 1982.

31. Winter, T.C.. 1981. **Uncertainties In Estimating The Water Balance Of Lakes.** Water Resources Bulletin, Vol. 17, No. 1, pp 82-115.

32 Vet, R.J., and S.G. Onlock. 1983. **The Canadian Air and Precipitation Monitoring Network (CAPMoN) Quality Assurance Plan for Precipitation Monitoring Systems**. Publication CSC 110.194-3-1, Prepared for Air Quality and Inter-Environmental Research Branch, Atmospheric Environment Service by Concord Scientific Corporation, Toronto, Canada. March 1983.

33. Volchock, H.L. and R.T. Graveson. 1976. **Wet /Dry Fallout Collection**: Proceedings of the Second Federal Conference on the Great Lakes, Great Lakes Basin Commission, March 25-27, pp 256-264.

1983 West Point Site Visitation Survey: Siting Summary

S.R. Dossett and D.S. Bigelow

This summary was compiled from field visitation forms designed and completed by Maj.s John Robertson, Richard Graham and Jerre Wilson of the Science Research Laboratory at the United States Military Academy (West Point). The Site Visitations summarized here were conducted by the West Point Site Visitation Team in the fall-summer of 1982-1983. The summary includes only those sites that were operating at the time of the visitation and only includes visits made before January 1984.

There were 115 sites operating during this part of the visitation program.

KEY:

NUMBER The NADP site number.

CAL CODE The site designation used by the Illinois State Water Survey's Central Analytical Laboratory (CAL).

NECESSARY ACTION Recommendations to improve site quality.

Y Sites meet all criteria.

R Sites meet criteria except rain gage is sited or installed incorrectly. Listed problems other than rain gage are considered insignificant.

O Sites meet criteria. Listed problems are considered insignificant.

U Site is considered an Urban site. Most of the listed problems are considered irrelevant to urban sites.

SITING CRITERIA Number of the NADP/NTN siting criteria not met. Blank indicates no violations.

ON SITE On Site Requirements (within 30 meters)

1. Recommended Installation of the collector is on the standard 3 foot high aluminum base over undisturbed ground. In areas having an accumulation of over 2 feet of snow per year, the collector may be raised off the ground on a platform. This platform will be no higher than the maximum anticipated snowpack. In general, platforms are discouraged.
2. The collector should be oriented with the WET side bucket to the west and the sensor pointing north.
3. Naturally vegetated, level areas are preferred, but grassed areas and slopes up to ± 15% will be tolerated. If possible, such ground cover should surround the collector for a distance of approximately 20 meters. The slope should be within the prescribed value in the ground cover area. In farm areas a vegetated buffer strip must surround the collector for at least 20 meters.
4. The base of the collector will not be enclosed.
5. Objects with sufficient mass to deflect the wind (with the exception of an alter wind shields) over 1 meter high will not be located within 5 meters of the collector.
6. The rain gage should be located within 30 meters of the collector, but no closer than 5 meters. It's orifice should be located within 1 foot of the same level as the orifice of the collector.
7. Collectors located in areas which normally receive snow will only have a snow roof installed on the moving lid of the collector when problems with opening and closing are encountered. Such a lid will be left on year round.
8. Annual vegetation will be maintained at less than 2 feet.

9. No object or structure shall project onto the collector or rain gage with an angle greater than 45 degrees from the horizontal (30 degrees is considered optimal, but 45 degrees is the highest angle acceptable). Therefore the distance from the sampler to the object must be at least equal to the height of the object (preferably twice the height of the object). Pay particular attention to anemometer towers and overhead wires.

LOCAL Local Requirements (within 1 km)

10. No surface storage of agricultural products, fuels, vehicles, or other foreign materials within 100 meters of the collector will be allowed. Parking lots and maintenance yards with frequent use are a particular problem.

11. Grazing animals and pasture will not be closer than 20 meters to the collector. Feedlots, dairy barns, etc, in which large concentrations of animals are housed will be no closer than 500 meters to the collector.

12. Frequent moving sources of pollution, such as air, ground, or water traffic or the medium on which they traverse (e.g. runway, taxiway, road, or navigable river) within 100 meters of the collector. The local road net around the site is of particular concern.

13. Residential type buildings should not be within a 30 degree cone.

REGN Regional Requirements (within 50 km)

14. Continuous industrial-type operations such as factories, chemical plants, power plants, etc will not be within 10 km of the collector. Additionally if the emissions sources are located in the general upwind direction (i.e the mean annual west-to-east flow in most cases) of the collector, then they should be no closer than 20 km to the collector.

15. The collector should not be located within 10 km of a moderate-sized suburban or urban area. A general definition of this classification is one having 10,000 or more people. This distance should be increased to 20 km if the urban area is in the general upwind direction of the collector. For the larger cities (i.e. populations greater than 75,000) the collector should be no closer than 20 km if it is in the upwind direction, and 40 km if it is in the downwind direction.

RECOMD ACTION West Point's Recommendation to meet minimum Site requirements.

ADJUS	Site requires minor adjustments.
MOVE	Site will need to move more than 30m to meet siting requirements.
CLOSE	Site cannot meet siting requirements and should be closed.

COLLECTOR

TYPE

ACM	Aerochem Metrics
LMD	Leonard Mold and Die

MODEL

101

201

301

RAIN GAGE

TYPE

5-780	Belfort 5-780 Universal Rain Gage
FRIEZ	Friez version of the Universal Rain Gage
CLIMO	Climotronics (tipping bucket) Rain Gage
STICK	8" NWS dip type stick gage
TIP	Tipping Bucket Rain Gage

EVNT	Rain Gage is equipped with an Event Pen

1983 West Point Visitation Siting Summary

SITE NUMBER	CAL CODE	NECESS ACTION	SITING CRITERIA			RECOMD ACTION	COLLECTOR		RAIN GAGE	
			REGN	LOCAL	ON SITE		TYPE	MODEL	MODEL	EVNT
020390	AK03	-----NOT VISITED-----								
030360	AZ99	R	-	-	356		ACM	301	5-780	YES
030370	AZ03	Y	-	-	-		ACM	301	5-780	YES
030620	AZ06	Y	-	-	-		ACM	301	5-780	YES
040260	AR02	-	14	10 12	156	MOVE	ACM	301	5-780	YES
041620	AR16	-	-	10 12	6	MOVE	ACM	301	5-780	YES
042700	AR27	-	15	12	1256	ADJ	ACM	301	STICK	NO
054200	CA42	UR	14 15	-	56		ACM	301	5-780	YES
054540	CA45	R	-	-	56		ACM	301	5-780	YES
057550	CA75	R	-	-	3569		ACM	301	5-780	YES
058840	CA88	R	14 15	12	256		ACM	201	FRIEZ	YES
058850	CA99	R	-	-	67		ACM	301	5-780	YES
060060	CO00	-	-	10	1259	MOVE	ACM	201	5-780	NO
061530	CO99	-	-	-	57		ACM	301	5-780	YES
061560	CO15	R	-	-	56		ACM	301	5-780	YES
061910	CO19	-	-	10	9	MOVE	ACM	301	5-780	YES
061911	CO98	-----NOT VISITED-----								
062120	CO21	-	-	10	69	MOVE	ACM	201	5-780	YES
062220	CO22	Y	-	-	-		ACM	201	5-780	YES
100360	FL03	O	14	10	-		ACM	301	5-780	NO
101190	FL11	-	-	10	6	ADJ	ACM	301	5-780	YES
114140	GA41	Y	-	-	-		ACM	301	5-780	YES
120080	HI00	-----NOT VISITED-----								
130340	ID03	-	-	10 12	13567	MOVE	ACM	301	5-780	YES
130480	ID04	R	-	-	16		ACM	201	5-780	YES
141160	IL11	Y	-	-	-		ACM	301	5-780	YES
141800	IL18	R	-	-	6		ACM	301	5-780	YES
141980	IL19	UR	-	-	6		ACM	301	FRIEZ	YES
143580	IL35	-	14 15	-	269	ADJ	ACM	201	5-780	YES
144740	IL47	R	-	-	2		ACM	201	5-780	NO
146340	IL63	R	-	11	16		ACM	201	5-780	YES
153421	IN99	UR	14	10 12	126		ACM	301	5-780	YES
154100	IN41	O	-	10	-		ACM	301	5-780	YES
173120	KS31	O	15	-	2		ACM	301	5-780	YES
182260	KY22	-----NOT VISITED-----								
190620	LA06	R	-	11	230		ACM	301	5-780	YES

SITE	CAL	NECESS	SITING CRITERIA			RECOMD	COLLECTOR		RAIN GAGE	
NUMBER	CODE	ACTION	REGN	LOCAL	ON SITE	ACTION	TYPE	MODEL	MODEL	EVNT
191260	LA12	R	-	11	126		ACM	301	5-780	YES
193060	LA30	R	-	-	6		ACM	301	5-780	YES
200011	ME98	R	-	-	256		ACM	301	5-780	YES
200045	ME00	-	14	10 12	5	MOVE	ACM	201	5-780	NO
200277	ME02	R	-	-	6		ACM	301	5-780	YES
200935	ME09	-	14	10	35689	MOVE	ACM	301	5-780	YES
211320	MD13	Y	-	-	-		ACM	301	5-780	NO
220155	MA01	-	-	-	1256	MOVE	ACM	301	5-780	YES
220815	MA08	O	-	-	28		ACM	301	5-780	YES
221325	MA13	UR	14 15	10 12	29		ACM	301	5-780	YES
230920	MI09	R	-	-	5		ACM	301	5-780	YES
232240	MI22	-	-	10 13	12569	MOVE	ACM	101	5-780	NO
232241	MI99					-----NOT VISITED-----				
232570	MI25	-	-	-	2569	MOVE	ACM	301	5-780	NO
232660	MI26	Y	-	-	-		ACM	301	5-780	YES
235340	MI53	-	-	-	25679	ADJ	ACM	301	5-780	YES
241660	MN16	-	-	-	24569	ADJ	ACM	301	5-780	NO
241840	MN18	R	-	-	256		ACM	301	5-780	YES
242720	MN27	R	-	-	126		ACM	301	5-780	YES
251460	MS14	-	14 15	10 12	1259	CLOS	ACM	201	5-780	NO
260380	MO03	-	-	-	29	ADJ	ACM	301	5-780	YES
260560	MO05	O	-	-	2		ACM	301	5-780	YES
270560	MT99	Y	-	-	-		ACM	301	5-780	YES
270570	MT05	-	-	-	569	ADJ	ACM	201	5-780	YES
271340	MT13	O	-	11	3		ACM	301	5-780	YES
281520	NE15	R	-	-	6		ACM	201	5-780	YES
300240	NH02	O	-	-	1		ACM	301	5-780	YES
312981	NJ99	UR	14 15	10 12	1256		ACM	201	5-780	YES
320720	NM07	Y	-	-	-		ACM	301	5-780	YES
320980	NM09	O	-	11	-		ACM	301	5-780	YES
330860	NY08	Y	-	-	-		ACM	201	5-780	YES
331000	NY10	Y	-	-	-		ACM	301	5-780	YES
331220	NY12	-	-	-	29	ADJ	ACM	301	5-780	YES
332020	NY20	-	-	11	2568	ADJ	ACM	301	5-780	YES
335140	NY51	-	-	-	???		ACM	301	5-780	YES
335240	NY52	R	-	-	6		ACM	301	5-780	YES
336500	NY65	O	-	12	-		ACM	301	5-780	YES
340320	NC03	R	-	10	6		ACM	201	CLIMO	YES
341180	NC11	*		12	26		ACM	201	5-780	YES
342500	NC25	-	-	-	59	MOVE	ACM	201	5-780	YES
343310	NC33	-	-	-	125	CLOS	ACM	201	5-780	YES
343460	NC34	R	-	12	6		ACM	201	5-780	YES
343560	NC35	-	-	10 12	56	ADJ	ACM	201	5-780	YES
344160	NC41	R	-	11	6		ACM	201	TIP	YES
350700	ND07	Y	-	-	-		ACM	301	5-780	YES
361760	OH17	R	-	10	26		ACM	201	5-780	YES
364900	OH49	R	-	10	356		ACM	201	5-780	YES
367160	OH71	-	14 15	-	56	MOVE	ACM	301	5-780	YES
371740	OK17	-	-	101112	9	MOVE	ACM	301	5-780	YES
372580	OK25	R	-	-	126		ACM	301	5-780	YES
380200	OR02	-	-	10	6	MOVE	ACM	301	5-780	YES

SITE NUMBER	CAL CODE	NECESS ACTION	SITING CRITERIA REGN	LOCAL	ON SITE	RECOMD ACTION	COLLECTOR TYPE	MODEL	RAIN GAGE MODEL	EVNT
380201	OR99	-	-	-	-	MOVE	ACM	301	5-780	YES
380260	OR98	R	-	-	12356		LMD		5-780	YES
380840	OR08	-	-	-	1369	CLOS	ACM	301	5-780	YES
381020	OR10	-	-	-	69	ADJ	ACM	301	5-780	YES
381120	OR11	R	-	-	346		ACM	301	5-780	YES
392940	PA29	Y	-	-	-		ACM	301	5-780	YES
394200	PA42	Y	-	-	-		ACM	201	5-780	YES
421880	SC18	-	15	10 12	1356	MOVE	ACM	201	5-780	YES
430060	SD00	-	15	10 12	569	MOVE	ACM	301	5-780	NO
440040	TN00	-	-	-	15	ADJ	ACM	201	5-780	NO
441190	TN11	-	-	12	69	ADJ	ACM	201	5-780	YES
450425	TX04	Y	-	-	-		ACM	301	5-780	YES
452180	TX21	R	-	-	56		ACM	301	5-780	YES
453800	TX38	Y	-	-	-		ACM	301	5-780	YES
455350	TX53	-	14 15	12	6	MOVE	ACM	201	5-780	NO
460280	UT02	R	-	-	26		ACM	301	5-780	YES
470100	VT01	R	-	-	2		ACM	301	5-780	YES
481300	VA13	-	-	-	1236	MOVE	ACM	201	5-780	YES
482890	VA28	R	-	-	256		ACM	301	5-780	YES
491410	WA14	-	-	10 12	569	ADJ	ACM	201	5-780	YES
501860	WV18	R	14	-	26		ACM	201	FRIEZ	NO
512800	WI28	R	-	-	1236		ACM	301	5-780	YES
513640	WI36	R	-	-	56		ACM	301	5-780	YES
513700	WI37	R	-	-	6		ACM	101	STICK	NO
520680	WY06	O	-	-	3		ACM	201	5-780	YES
520820	WY99	O	14	-	-		ACM	301	5-780	YES
520860	WY08	O	-	10 11	-		ACM	201	5-780	YES
530190	AS01	-----NOT VISITED-----								
TOTALS	115	70	19	40	86	ADJ 14 MOVE 20 CLOS 3	3	3	15	
PERCENT		61%	17%	35%	75%	ADJ 13% MOV 18% CLOS 3%	3%	3%	13%	

Tally by criteria (see KEY)

Criteria	no	%	
Y	16	14	No problems
R	41	36	rain gage
O	12	10	insignificant
U	5	4	urban sites

Criteria	no	%	problem
1	21	18	on platform
2	4	3	WET bucket not west
3	14	12	cover
4	2	2	base enclosed
5	38	33	too much mass
6	64	56	rain gage close
7	4	3	snow roof
8	3	3	cover/trim
9	22	19	45 degree rule
10	26	23	storage too close
11	9	8	grazing animals
12	21	18	transportation sources
13	1	1	buildings too close
14	15	13	industrial sources
15	12	10	urban site

These sites were visited even though they had closed before the visitation took place. They are not included in the 115 sites counted above.

SITE	CAL	NECESS	SITING CRITERIA			RECOMD	COLLECTOR		RAIN GAGE	
NUMBER	CODE	ACTION	REGN	LOCAL	ON SITE	ACTION	TYPE	MODEL	MODEL	EVNT
53460	CA34	-	-	10 12	2356	-	ACM	-	5-780	-
58500	CA85	-----NOT VISITED----								
381780	OR17	-	-	10 12	5	-	ACM	-	5-780	-

1983 West Point Site Visitation Survey: Equipment Summary

Scott R. Dossett

This summary was compiled from field visitation forms designed and completed by Maj.s John Robertson, Richard Graham and Jerre Wilson of the Science Research Laboratory at the United States Military Academy (West Point). The Site Visitations summarized here were conducted by the West Point Site Visitation Team in the fall-summer of 1982-1983. The summary includes only those sites that were operating at the time of the visitation and only includes visits made before January 1984.

There were 115 sites operating during this part of the visitation program.

KEY:

NUMBER	The NADP site number.
CALCODE	The site designation used by CAL.
RECOMD	Recommendations to improve sampling equipment.

M	Replace Motorbox
S	Replace Sensor
W	Add Counter Weight. This adjustable weight or series of weights helps maintain lid seal pressure on the bucket and also decrease the mechanical stress on the Aerochem Metrics drive motor.
TS	Replace Tension Springs. The pressure exerted by these springs maintain the lid to bucket seal, insuring minimum dust incursion into the bucket during dry periods.

COLLECTOR

Power

110AC	Line power
110ACB	Line power with a battery backup.
12DC	Battery Powered
SOLAR	Solar charged battery system

Snow Roof

YES	Collector lid is equipped with a peaked snow roof.
POLY	Collector lid is made of polycarbonate instead of aluminum.
NO	Collector lid does not have a peaked snow roof.

Tie Downs

SS	Stainless Steel
RUBBR	Rubber bungie
NONE	No Tie Down was in use

Sensor

Type

OLD	4x5 large old style sensor.
NEW	3.5 new smaller style sensor.
ohms	Which resistor triggered the collector. Choices were 51, 56, 68.1, 75, 100, 150 and 1000 ohms.

Clutch

Type — Diameter of the brass collar in inches. Aerochem Metrics began using a larger diameter collar in early 1983.

Condition — Lid Tension pressure is a qualitative measure of the pressure, or sealing ability, of the lid to bucket. Measurements were made both by using a Spring scale, and, by placing rain gage calibration weights on the lid of the collector and determining how much weight could be lifted.

OK	Clutch condition was ok
WRN	Clutch was worn and needed replacing.

RAIN GAGE

CAL

OK	The calibration and/or turn-over point (T.O.) on the rain gage.
T.O.	Rain gage was within tolerance.
ADJ	The calibration and/or turn-over point required adjustment. The actual reading of the turn-over point is given in some instances.

1983 West Point Visitation Equipment Summary

Identification			Wet Dry Collector									Rain Gage		
Site Number	CAL Code	RECOMD	Power	Snow Roof	Tie Downs	Sensor Type	ohms	Clutch Type	Condition			Alter Shield	Calibration CAL.	T.O.
020390	AK03		-----NOT VISITED-----											
030360	AZ[illegible]		12DC	NO	SS	NEW	75	1.5	2700	1640	OK	YES	OK	ADJ
030370	AZ03	S	110AC	NO	SS	NEW	56	1.5	2900	1640	OK	NO	OK	OK
030620	AZ06	TS	110AC	NO	SS	OLD	75	1.0	1900	1640	OK	NO	OK	ADJ
040260	AR02	M TS	110AC	NO	NONE	NEW	68	1.5	1600	1640	OK	NO	OK	OK
041620	AR16	M	110AC	YES	SS	NEW	68	1.0	3400	NO	OK	NO	ADJ	ADJ
042700	AR27	M TS	110AC	NO	SS	NEW	75	1.0	1600	1640	OK	NO		
054200	CA42	MS	110ACB	NO	SS	NEW	56	1.0		1640	WRN	NO	OK	OK
054540	CA45	M	110AC	NO	NONE	OLD	75	1.0		NO	WRN	YES	OK	OK
057550	CA75	MS TS	110AC	NO	NONE	OLD	51	1.0		1640	OK	NO	OK	OK
058840	CA88	TS	110AC	NO	SS	OLD	51	1.0	1500	1640	OK	NO	OK	NO
058850	CA99	MS TS	110AC	NO	NONE	NEW	75	1.0	1700	1640	OK	NO	OK	OK
060060	CO00		110AC	NO	RUBBR	OLD	1MEG	1.0	2600	1640	OK	YES	OK	OK
061530	CO99		SOLAR	YES	NONE	NEW	57	1.5	2400	1640	OK	NO	ADJ	ADJ
061560	CO15	S	SOLAR	YES	?????	OLD	75	1.0	2200	1640	OK	NO	OK	OK
061910	CO19	M	110AC	NO	NONE	NEW	75	1.0	2500	NO		NO	OK	OK
061911	CO98		------NOT VISITED-----											
062120	CO21	M	110AC	YES	NONE	OLD	57	1.0	2100	1640		NO	OK	5.80
062220	CO22		110AC	NO	NONE	NEW	57	1.0	2400	1640	OK	YES	OK	OK
100360	FL03	S	SOLAR	NO	NONE	NEW	56	1.0	4000	NO	OK	NO	OK	OK
101190	FL11		110AC	NO	SS	OLD	100	1.0	1900	1640	OK	NO	ADJ	ADJ
114140	GA41		110AC	NO	SS	NEW	56	1.5	2700	1640	OK	NO	OK	OK
120080	HI00		-----NOT VISITED-----											
130340	ID03	MS TS	110AC	NO	SS	OLD	75	1.0	LOW	1640	OK	NO	OK	5.50
130480	ID04		12VDC	YES	SS	NEW	75	1.5	4000	NO	OK	NO	OK	OK
141160	IL11		110ACB	YES	SS	NEW	75	1.5	3700	NO	OK	NO	OK	OK
141800	IL18		110AC	NO	SS	NEW	57	1.0	2400	1640	OK	NO	OK	OK
141980	IL19		110AC	NO	SS	NEW	75	1.0	2200	1640	WRN	NO	ADJ	NO

Identification			Wet Dry Collector									Rain Gage		
Site Number	CAL Code	RECOMD	Power	Snow Roof	Tie Downs	Sensor		Clutch				Alter Shield	Calibration	
						Type	ohms	Type	Condition				CAL.	T.O.
143580	IL35		110AC	NO	SS	OLD	75	1.0	2200	1640	OK	NO	OK	OK
144740	IL47	MS	110AC	NO	SS	OLD	56	1.0	2100	1640	OK	NO	OK	OK
146340	IL63		110AC	NO	SS	OLD	68	1.5	2400	1640	OK	NO	OK	ADJ
153421	IN99	M TS	110AC	NO	SS	NEW	68	1.0	1600	1640	WRN	NO	ADJ	5.95
154100	IN41		110AC	NO	SS	NEW	75	1.5	2900	1640	OK	NO	OK	OK
173120	KS31		110AC	NO	SS	NEW	75	1.5	2800	1640	OK	NO	OK	OK
182260	KY22					-----NOT VISITED-----								
190620	LA06		110AC	NO	SS	NEW	75	1.0	2500	1640	OK	NO	CAL	OK
191260	LA12		110AC	NO	SS	NEW	57	1.5	2200	1640	OK	NO	OK	OK
193060	LA30		110AC	NO	SS	NEW	68	1.5	2500	1640	OK	NO	OK	6.10
200011	ME98		110AC	YES	NONE	NEW	75	1.0		1640	WRN	NO	OK	OK
200045	ME00	MS	110ACB	NO	RUBBR	OLD	68	1.0		1640	WRN	YES	OK	5.80
200277	ME02	MS	110AC	NO	NONE	NEW	75	1.0	2100	1640	WRN	NO	OK	ADJ
200935	ME09		110AC	NO	NONE	OLD	75	1.0	2500	1640	WRN	NO	OK	OK
211320	MD13		110AC	NO	SS	NEW		1.5	3000		OK	NO	NOT	CKD
220155	MA01		110AC	NO	RUBBR	NEW	68	1.0	2900	1640	OK	NO	OK	OK
220815	MA08	M	SOLAR	POLY	NONE	NEW	68	1.0	2600	1640	WRN	YES	OK	OFF
221325	MA13		110AC	POLY	SS	NEW	75	1.5	2600	1640	OK	NO	OK	OK
230920	MI09	TS	110AC	YES	RUBBR	NEW	75	1.0	1500		WRN	NO	OK	OK
232240	MI22	TS	110AC	YES	NONE	OLD	75	1.0	1600	1640	OK	NO	OK	OK
232241	MI99					-----NOT VISITED-----								
232570	MI25		110AC	NO	NONE	OLD	75	1.0	2600	1640	OK	NO	OK	5.75
232660	MI26	S	110AC	NO	SS	OLD	75	1.0	3200	1640	OK	NO	ADJ	ADJ
235340	MI53	M TS	110AC	YES	NONE	NEW	75	1.5		1640	OK	YES	ADJ	OK
241660	MN16	M TS	110AC	YES	NONE	OLD	56	1.0	900	LOW	OK	NO	OK	OK
241840	MN18	TS	110AC	YES	NONE	NEW	68	1.0	1600	1640	OK	NO	NOT	CKD
242720	MN27		110AC	NO	RUBBR	NEW	57	1.5	3200	1640	OK	NO	ADJ	OK
251460	MS14	S	110AC	NO	NONE	NEW	75	1.5	3000	NO	OK	NO	OK	5.93
260380	MO03		12VDC	NO	SS	NEW	75	1.5	3000	1640	OK	NO	OK	5.95
260560	MO05		12VDC	NO	SS	NEW	75	1.5	2300	1640	OK	NO	OK	5.83
270560	MT99		110AC	NO	SS	NEW	75	1.5	2200	1640	OK	NO	OK	5.80
270570	MT05	W	110AC	YES	SS	NEW	75	1.5	5000	NO	OK	NO	OK	5.78
271340	MT13		110AC	NO	SS	NEW	75	1.0	3000	1640	OK	NO	OK	OK
281520	NE15	MS	110AC	NO	SS	OLD	100	1.0	2500		WRN	NO	NOT	CKD
300240	NH02	M	110AC	HTD	NONE	OLD	75	1.0	2400		WRN	YES	OK	5.95
312981	NJ99		110AC	NO	SS	NEW	68	1.0	2200	1640	OK	NO	ADJ	ADJ
320720	NM07		110AC	NO	SS	NEW	68	1.5	2700	1640	OK	NO	OK	OK
320980	NM09		SOLAR	NO	SS	NEW	75	1.5	2600	1640	OK	NO	OK	OK
330860	NY08		110AC	NO	NONE	OLD	75	1.0	1900	1640	OK	NO	ADJ	ADJ
331000	NY10		110AC	YES	RUBBR	NEW	75	1.0	3000	1640	OK	NO	OK	ADJ
331220	NY12	S	110AC	HTD	RUBBR	OLD		1.0	2400	822	ADJ	NO	OK	5.90
332020	NY20	M	110AC	YES	NONE	NEW	75	1.0	2000	1640	WRN	NO	OK	ADJ
335140	NY51					-----NO REPORT ON FILE-----								
335240	NY52		110AC	YES	NONE	OLD	68	1.0	2200	1640	OK	NO	NOT	CKD
336500	NY65		110ACB	YES	RUBBR	NEW	75	1.0	2600	1640	OK	NO	OK	ADJ
340320	NC03	MS	110AC	NO	NONE	NEW	68	1.0	2300	NO	OK	NO	NOT	CKD
341180	NC11		110AC	NO	SS	OLD	68	1.0	2400	1640	OK	NO	RAINING	
342500	NC25		110AC	NO	NONE	OLD	68	1.0	2100	1640	OK	NO	OK	OK
343310	NC33	MS TS	110AC	NO	NONE	OLD	57	1.0	1500	1640	OK	NO	OK	6.10
343460	NC34	M	110AC	NO	SS	NEW	56	1.0	3400	1640	WRN	NO		

Identification			Wet Dry Collector									Rain Gage		
Site Number	CAL Code	RECOMD	Power	Snow Roof	Tie Downs	Sensor Type	ohms	Type	Clutch Condition			Alter Shield	Calibration CAL.	T.O.
343560	NC35		110AC	NO	SS	NEW	68	1.0	2400	NO	OK	NO	5.06	5.95
344160	NC41	M TS	110AC	NO	SS	NEW		1.0	1800	1640	OK	NO		
350700	ND07		110ACB	NO	SS	NEW	68	1.0	2600	1640	OK	NO	OK	OK
361760	OH17	M TS	110AC	YES	SS	OLD	75	1.0	1900	1640	OK	NO	OK	OK
364900	OH49	M	110AC	NO	NONE	NEW	68	1.0	1900	NO	WRN	NO	OK	OK
367160	OH71		110AC	NO	NONE	OLD	75	1.0	1900	1640	OK	NO	ADJ	OK
371740	OK17	M TS	110AC	NO	NONE	NEW	75	1.5	1900	1640	OK	NO	OK	OK
372580	OK25		110AC	NO	SS	NEW	75	1.5	2700	1600	OK	YES	OK	OK
380200	OR02	MS TS	110AC	NO	SS	NEW	150	1.0	1700	820	WRN	NO	OK	OK
380201	OR99	M	110AC	NO	SS	NEW	68	1.0	2400	1640	WRN	NO	ADJ	4.00
380260	OR98	M	12DC	NO	NONE	LMD						YES	NOT	CKD
380840	OR08	TS	110AC	NO	SS	NEW	68	1.0	1500	820	OK	NO	OK	OK
381020	OR10	MS	12DC	NO	SS	OLD	100	1.0	2400	820	WRN	YES	OK	OK
381120	OR11	M TS	110AC	NO	SS	NEW	75	1.0		1640	WRN	NO	OK	5.95
392940	PA29		110AC	HTD	NONE	NEW	68		2600	1640	OK	NO	OK	5.50
394200	PA42		110AC	YES	SS	NEW	56	1.0	4000	NO	WRN	YES	OK	5.93
421880	SC18	M TS	110AC	NO	SS	OLD	56	1.0	1800	1640	OK	NO	OK	ADJ
430060	SD00	M TS	110AC	NO	NONE	OLD	75	1.5		1640	OK	YES		
440040	TN00	S	110AC	NO	NONE	OLD	56	1.0			OK	NO	OK	OK
441190	TN11	M TS	110AC	NO	NONE	OLD	56	1.0	1600	NO	OK	NO	OK	ADJ
450425	TX04		110AC	NO	SS	OLD	75	1.0	2500	1640	OK	NO	OK	OK
452180	TX21		110AC	NO	SS	NEW	75	1.5	2500	1640	OK	NO	OK	OK
453800	TX38	M?	110AC	NO	SS	NEW	75	1.0	2600	1640	OK	YES	OK	5.97
455350	TX53		110AC	NO	SS	OLD	75	1.0	2600	1640	OK	NO	OK	6.05
460289	UT02	S	110AC	NO	SS	NEW	75	1.5	2300	1640	OK	YES	ADJ	OK
470100	VT01	M	110AC	HTD	NONE	NEW	75	1.0	1900	1640	OK	NO	ADJ	ADJ
481300	VA13	W	110AC	YES	WIRE	NEW	68	1.0	4000	NO	OK	NO	OK	OK
482890	VA28	S	110AC	NO	SS	NEW	75	1.5	2500	1640	OK	NO	ADJ	ADJ
491410	WA14		110AC	NO	SS	NEW	75	1.0	2600	1640	OK	NO	OK	ADJ
501860	WV18		110AC	YES	SS	NEW	75	1.0	4000	NO		NO		
512800	WI28		110AC	YES	SS	NEW	75	1.5		1640	OK	NO	OK	OK
513640	WI36	M	110AC	YES	NONE	NEW	75	1.0	2000		WRN	NO	OK	ADJ
513700	WI37	M W	110AC	HTD	NONE	NEW	75	1.0	1900	1640	OK	NO		
520680	WY06		110AC	NO	SS	NEW	75	1.5	2500	1640	OK	NO	OK	ADJ
520820	WY09		110AC	NO	NONE	NEW	68	1.0	2000	1640	OK	NO	NOT	CKD
520860	WY08		110AC	NO	SS	NEW	75	1.5	1900	NO	WRN	NO	ADJ	OK
530190	AS01		-----NOT VISITED-----											

Tally of Rain Gage Characteristics												
Rain Gage Type					Calibration			Turn over Point				
Belfort	FRIEZ	STICK	CLIMO	TIP	OK	ADJ	NOT CHECKED	OK	ADJ	NOT CHECKED	EVNT PEN	ALTER SHIELD
99	3	2	1	1	76	17	14	50	20	14	91	15
86%	3%	2%	1%	1%	66%	15%	12%	43%	17%	12%	79%	13%

Tally of Collector Characteristics: Collector Type and Power

TOTAL	RECOMD				ACM			LMD	Voltage				SNOW
SITES	M	S	W	TS	301	201	101		110AC	110ACB	12DC	SOLAR	ROOF (HTD)
115	39	21	3	23	72	33	2	1	97	5	6	5	24 (5)
	34%	18%	3%	20%	63%	29%	2%	1%	84%	4 %	5 %	4%	21%(4%)

Tally of Collector Characteristics (continued)

Tie Downs		Sensor Types			Resistances (kohms) required to trigger sensor							
SS	RUBBR	OLD	NEW	LMD	51	56	68	75	100	150	1000	1 MEG
	60	8	35	72	1	2	18	23	56	3	1	1
	52%	8%	30%	63%	1%	2%	16%	20%	49%	3%	1%	1%

Tally of Collector Characteristics (continued)

Clutch					Lid Tension				
Type		Condition			Percentiles				
1.0"	1.5"	OK	WRN	NOT CKD	MIN	0.25	0.50	0.75	MAX
74	32	81	22	5	900	1900	2400	2650	5000
					MEAN = 2432				

I. Annual Summary Criteria for Weighted Averages by Year

The following tables are computed using the data completeness criteria for including a site in an NADP Annual Data Summary that were developed by NADP Subcommittee 2, Data Management and Analysis, in preparation of the 1982 NADP Annual Data Summary of Precipitation Chemistry in The United States (16). The tables correspond to data archived at the NADP Coordinator's Office at the time this report was started, Spring of 1985. Subsequent Annual reports issued by the NADP/NTN program will reflect more current data.

Site data is arranged in number order with the sites passing all of the Annual Summary Criteria given first. The following key to the criteria is taken from the 1982 report.

A. Criteria for Including a Site in the Annual Summary

Four criteria form the basis for the decision to include the data from a site in the annual summary. All four must be met. These criteria are listed below, and their numerical values by site are listed in Table 1:

1. There must be valid samples for at least 75% of the summary period.
2. For at least 90% of the summary period, there must be precipitation amounts either from the rain gage or from the sample volume.
3. There must be valid sampler for at least 75% of the total precipitation amount which was reported for the summary period.
4. For the entire summary period the total precipitation from the sample volume must be at least 75% of the total precipitation from the rain gage for all valid samples where both values are available.

Criteria 1 and 2 assure that measurements on valid wet deposition samples and of precipitation amounts were reported for a minimum acceptable fraction of the year. This requires a properly operating wet/dry collector and rain gage. Criteria 1 and 3 assure that there were precipitation chemistry to represent not only 75% of the summary period, but also 75% of the precipitation that was estimated to have occurred during the summary period. The fourth criterion sets an acceptable range for the collection efficiency of the wet/dry collectors relative to the rain gage. This assures some consistency in the operation of both the rain gage and the collector.

It is important to recognize that if all of the criteria were satisfied at the lower limit of acceptability, the annual summary could still account for less than 75% of the actual precipitation at a site. This is because the 90% precipitation coverage criterion is based on time, and there may be no record of the amount of precipitation missed during the unsampled 10% of the year. Where the precipitation coverage is 100%, however, these criteria assure that at least 75% of the annual precipitation will be represented by valid data. In addition to the above criteria, NADP siting criteria must have been satisfied.

B. Tables

1978 Annual Summary Criteria for Weighted Averages

Dates include weeks beginning: JUL 1978 through 28 DEC 1978

ANNUAL SUMMARY CRITERIA

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
058840	Davis Site	7.713	15.427	54.360	101.622	12.522	11	781017	79 1 2	77
062120	Manitou	11.570	15.427	100.000	54.706	4.357	11	781017	79 1 2	77
100020	Austin-Cary Forest	15.427	15.427	100.000	81.601	20.828	12	781010	79 1 2	84
100360	Bradford Forest	19.284	19.284	100.000	101.855	14.047	12	781010	79 1 2	84
114140	Georgia Station	17.355	21.212	100.000	98.455	21.386	13	7810 3	79 1 2	91
235340	Wellston	15.427	21.212	80.216	37.464	16.180	12	781010	79 1 2	84
241660	Marcell Experimental	28.926	30.854	99.739	90.417	29.135	26	78 7 6	79 1 2	180
281520	Mead	19.559	27.273	92.109	78.000	8.052	23	78 725	79 1 2	161
300240	Hubbard Brook	40.496	40.496	100.000	93.940	39.978	23	78 725	79 1 2	161
332020	Huntington Wildlife	17.582	17.582	100.000	80.512	19.124	9	781031	79 1 3	64
340320	Lewiston	13.736	13.736	100.000	105.715	19.146	9	781031	79 1 3	64
342500	Coweeta	22.865	22.865	100.000	92.543	41.782	26	78 7 5	79 1 2	181
343460	Piedmont Research St	13.499	15.427	98.600	89.576	21.793	11	781017	79 1 2	77
343560	Clinton Crops Resear	19.284	19.284	100.000	94.391	24.003	10	781024	79 1 2	70
344160	Finley (a)	17.355	23.140	96.390	103.730	21.107	13	7810 3	79 1 2	91
344161	Finley (b)	17.355	23.140	96.390	101.299	21.107	13	7810 3	79 1 2	91
361760	Delaware	17.355	23.140	97.983	64.804	31.115	13	7810 3	79 1 2	91
364900	Caldwell	26.997	26.997	100.000	100.178	33.630	14	78 926	79 1 2	98
367160	Wooster	26.997	26.997	100.000	97.371	26.873	14	78 926	79 1 2	98
392940	Kane Experimental Fo	26.997	28.926	89.207	88.162	47.068	24	78 718	79 1 2	168
481300	Horton's Station	19.284	21.212	99.960	83.259	31.684	23	78 725	79 1 2	161
501860	Parsons	50.000	50.000	100.000	93.796	72.644	26	78 7 5	79 1 3	182
1978 Averages 22 sites		21.139	23.594	95.680	87.882					
1978 Medians 22 sites		18.433	22.030	100.000	93.170					
1978 Number of sites passed		0	0	21	19					
1978 Number of sites failed		22	22	1	3					

1978	0	sites passed all criteria
1978	22	sites failed at least one criteria

1979 Annual Summary Criteria for Weighted Averages.

Dates include weeks beginning 4 JAN 1979 through 28 DEC 1979

ANNUAL SUMMARY CRITERIA

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
241660	Marcell Experimental	86.575	94.247	97.685	95.250	76.809	52	79 1 2	80 1 2	365
300240	Hubbard Brook	86.301	90.411	96.593	91.886	119.280	52	79 1 2	80 1 2	365
332020	Huntington Wildlife	95.879	95.879	100.000	122.738	89.639	52	79 1 3	80 1 2	364
340320	Lewiston	96.429	100.000	99.902	97.725	129.716	52	79 1 3	80 1 2	364
342500	Coweeta	94.247	94.247	100.000	92.082	222.538	52	79 1 2	80 1 2	365
343560	Clinton Crops Resear	90.411	94.247	98.237	95.783	128.941	52	79 1 2	80 1 2	365
344160	Finley (a)	88.493	92.329	99.981	89.319	131.179	52	79 1 2	80 1 2	365
361760	Delaware	92.329	96.164	99.614	88.494	118.301	52	79 1 2	80 1 2	365
364900	Caldwell	88.493	92.329	99.994	99.375	114.255	52	79 1 2	80 1 2	365
367160	Wooster	88.493	94.247	99.578	97.854	93.358	52	79 1 2	80 1 2	365
501860	Parsons	98.077	100.000	99.961	90.146	131.648	52	79 1 3	80 1 2	364
030180	Tombstone	27.072	30.939	98.939	94.840	14.017	40	79 327	80 1 1	280
054540	Hopland	10.559	21.488	99.092	93.306	49.813	13	7910 3	80 1 2	91
058840	Davis Site	52.055	57.808	97.406	95.101	49.441	52	79 1 2	80 1 2	365
061560	Sand Spring	58.127	61.983	89.169	85.514	28.142	41	79 320	80 1 2	288
062120	Manitou	42.582	69.231	71.791	69.854	36.974	52	79 1 2	80 1 1	364
062220	Pawnee	44.199	55.801	94.709	84.699	33.094	32	79 522	80 1 1	224
100020	Austin-Cary Forest	82.692	86.538	92.621	99.581	152.497	52	79 1 2	80 1 1	364
100360	Bradford Forest	82.692	82.692	100.000	92.001	119.298	52	79 1 2	80 1 1	364
114140	Georgia Station	80.274	82.192	99.797	95.530	124.896	52	79 1 2	80 1 2	365
141160	Bondville	65.746	75.414	92.792	87.042	81.404	44	79 227	80 1 1	308
143580	SIU	38.504	38.504	100.000	92.472	42.112	22	79 731	791231	153
146340	Dixon Springs Agricu	71.350	76.860	97.297	92.478	117.532	48	79 130	80 1 2	337
200935	Greenville Station	5.785	11.846	49.717	-1.000	9.971	6	791120	80 1 2	43
230920	Douglas Lake	42.975	42.975	100.000	92.180	48.083	26	79 7 3	80 1 2	183
232660	Kellogg Biological S	46.556	48.485	99.974	96.765	48.184	27	79 626	80 1 2	190
235340	Wellston	53.425	80.000	75.021	89.307	68.083	53	79 1 2	80 1 2	365
242720	Lamberton	69.041	78.630	95.615	98.174	77.893	52	79 1 2	80 1 2	365
281520	Mead	69.315	80.822	99.451	98.099	57.829	52	79 1 2	80 1 2	365
330860	Aurora Research Farm	65.659	65.659	100.000	96.256	74.636	37	79 417	80 1 3	261
335140	Stilwell Lake	42.424	43.526	94.836	79.457	73.787	27	79 626	80 1 2	190
343460	Piedmont Research St	75.068	82.740	99.883	96.570	120.536	52	79 1 2	80 1 2	365
344161	Finley (b)	73.151	75.068	99.989	90.764	112.358	52	79 1 2	80 1 2	365
392940	Kane Experimental Fo	53.699	82.466	66.658	94.302	113.893	52	79 1 2	80 1 2	365
394200	Leading Ridge	61.708	63.636	99.985	94.074	86.501	36	79 425	80 1 2	252
421880	Clemson	62.554	73.554	88.947	99.087	114.903	41	79 327	80 1 2	281
481300	Horton's Station	82.692	87.363	99.955	111.347	93.089	52	79 1 2	80 1 1	364
1979 Averages 37 sites		66.881	72.982	94.489	91.323					
1979 Medians 37 sites		69.315	80.000	99.578	94.074					
1979 Number of sites passed		16	11	35	36					
1979 Number of sites failed		21	26	2	1					

1979	11	sites passed all criteria
1979	26	sites failed at least one criteria

1980 Annual Summary Criteria for Weighted Averages.

Dates include weeks beginning 4 JAN 1980 through 28 DEC 1980

ANNUAL SUMMARY CRITERIA

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
146340	Dixon Springs Agricu	87.052	92.562	99.908	90.615	84.559	52	80 1 2	801230	363
300240	Hubbard Brook	86.777	92.286	96.034	99.086	89.662	52	80 1 2	801230	363
330860	Aurora Research Farm	85.083	90.331	99.618	92.795	79.576	52	80 1 3	801230	362
331220	Knobit	76.860	90.358	89.377	95.732	64.784	52	80 1 2	801230	363
332020	Huntington Wildlife	78.788	90.358	87.374	121.354	73.322	52	80 1 2	801230	363
340320	Lewiston	90.358	94.215	95.025	85.014	87.304	52	80 1 2	801230	363
342500	Coweeta	92.286	96.143	98.581	92.601	157.526	52	80 1 2	801230	363
343460	Piedmont Research St	92.286	96.143	98.773	94.190	99.828	52	80 1 2	801230	363
343560	Clinton Crops Resear	96.143	100.000	99.968	88.658	116.520	52	80 1 2	801230	363
361760	Delaware	88.430	96.143	99.891	93.242	108.599	52	80 1 2	801230	363
364900	Caldwell	88.430	94.215	96.964	103.185	97.236	52	80 1 2	801230	363
367160	Wooster	88.430	96.143	97.263	95.236	90.505	52	80 1 2	801230	363
394200	Leading Ridge	92.286	94.215	99.986	92.229	92.484	52	80 1 2	801230	363
501860	Parsons	96.143	98.072	98.789	92.170	123.774	52	80 1 2	801230	363
513640	Trout Lake	83.380	89.197	99.827	92.930	73.488	49	80 122	801230	343
020390	Denali (McKinley) Na	42.659	52.355	98.163	97.511	27.648	28	80 617	801230	196
030180	Tombstone	23.077	25.000	99.968	102.087	19.641	52	80 1 1	801230	364
030620	Organ Pipe Cactus Na	28.809	34.626	98.485	91.570	5.043	37	80 415	801230	259
042700	Fayetteville	42.659	42.659	100.000	95.752	47.144	33	80 513	801230	231
053460	Bishop	13.573	30.194	36.063	71.233	5.424	36	80 415	801230	259
054540	Hopland	59.504	63.361	99.226	95.331	82.094	52	80 1 2	801230	363
057550	Sequoia National Par	27.147	29.086	99.967	98.524	13.729	25	80 7 8	801230	175
058500	Channel Islands Nati	6.094	7.756	98.631	97.769	2.884	23	80 722	801230	161
058840	Davis Site	40.220	40.220	100.000	95.183	40.538	52	80 1 2	801230	363
060060	Alamosa	28.809	38.227	94.431	90.252	10.704	36	80 422	801230	252
061560	Sand Spring	69.146	74.656	98.804	83.708	29.676	52	80 1 2	801230	363
061910	Rocky Mountain Natio	34.903	46.537	86.019	98.710	14.446	31	80 529	801230	215
062120	Manitou	38.462	59.615	63.779	80.082	37.552	52	80 1 1	801230	364
062220	Pawnee	59.615	79.396	98.986	79.201	32.533	52	80 1 1	801230	364
100020	Austin-Cary Forest	67.857	88.736	87.824	89.968	99.300	52	80 1 1	801230	364
100360	Bradford Forest	54.121	77.198	77.838	93.159	93.753	52	80 1 1	801230	364
101190	Everglades National	29.363	35.180	95.941	94.576	63.833	28	80 617	801230	196
114140	Georgia Station	76.860	78.788	98.735	109.034	104.394	52	80 1 2	801230	363
120080	Mauna Loa	32.687	36.842	98.368	84.751	13.221	29	80 610	801230	203
130340	Craters of the Moon	24.931	32.133	90.051	107.446	12.021	18	80 822	801230	130
141160	Bondville	84.615	86.538	99.967	92.810	75.260	52	80 1 1	801230	364
141980	Argonne	65.651	71.468	99.797	96.489	81.492	42	80 311	801230	294
143580	SIU	73.151	80.822	99.556	90.771	75.571	52	791231	801230	365
144740	Salem	58.172	62.050	99.359	91.948	47.553	37	80 415	801230	259
153420	Indiana Dunes Nation	40.720	44.598	99.951	74.647	51.995	24	80 715	801230	168
200010	Acadia National Park	11.634	11.634	100.000	85.368	19.900	6	801118	801230	42
200045	Caribou	48.753	64.266	79.973	99.632	58.980	37	80 414	801230	260
200277	Bridgton	19.391	21.330	99.932	98.847	18.578	13	80 930	801230	91
200935	Greenville Station	48.760	82.645	77.379	95.544	78.300	52	80 1 2	801230	363
230920	Douglas Lake	73.003	82.645	91.620	96.661	49.402	52	80 1 2	801230	363
232240	Houghton	15.512	15.512	100.000	75.731	7.773	10	801026	801230	65

1980 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
232570	Isle Royale National	13.573	17.452	94.694	100.514	18.186	20	80 812	801230	140
232660	Kellogg Biological S	75.207	82.645	98.121	97.122	79.782	52	80 1 2	801230	363
235340	Wellston	69.421	96.419	75.669	95.754	83.048	52	80 1 2	801230	363
241660	Marcell Experimental	74.931	82.645	99.704	87.687	59.740	52	80 1 2	801230	363
241840	Fernberg	7.756	11.634	81.024	46.553	2.540	6	801118	801230	42
242720	Lamberton	67.493	75.207	99.890	93.416	46.000	52	80 1 2	801230	363
251460	Meridian	44.321	58.172	92.109	82.756	90.437	37	80 415	801230	259
270570	Glacier Fire Weather	44.598	54.294	80.501	91.958	56.275	30	80 6 3	801230	210
281520	Mead	65.565	71.350	98.195	95.183	46.553	52	80 1 2	801230	363
312980	Princeton	30.194	34.349	96.322	96.478	22.784	21	80 8 6	801230	146
331000	Chautauqua	42.659	54.294	91.464	96.942	61.224	29	80 610	801230	203
335240	Bennett Bridge	19.668	48.476	43.404	95.847	69.621	29	80 610	801230	203
336500	Jasper	77.562	83.380	99.782	94.726	61.107	45	80 219	801230	315
335140	Stilwell Lake	84.848	84.848	100.000	88.642	102.437	52	80 1 2	801230	363
341180	Research Triangle In	9.695	11.634	73.027	90.789	6.121	11	801014	801230	77
343310	Research Triangle Pa	52.355	58.449	97.331	86.969	57.124	37	80 415	801230	259
344160	Finley (a)	84.573	88.430	98.719	94.258	87.170	52	80 1 2	601230	363
344161	Finley (b)	22.992	22.992	100.000	83.594	29.540	13	80 1 2	80 4 1	90
380200	Alsea Guard Ranger S	75.414	79.282	96.210	97.850	121.991	52	80 1 3	801230	362
380201	Schmidt Farm	67.680	77.901	84.145	101.280	80.840	52	80 1 3	801230	362
380840	Lost Creek Dam	15.512	19.391	93.112	86.934	25.451	10	801021	801230	70
381020	H. J. Andrews Experi	44.598	46.537	99.859	93.806	89.991	33	80 513	801230	231
381120	Vines Hill	17.452	32.964	50.354	88.651	9.591	23	80 715	801230	168
381780	Pendleton	38.781	53.463	81.932	85.784	18.352	37	80 415	801230	259
392940	Kane Experimental Fo	73.278	83.196	90.715	93.901	103.682	52	80 1 2	801230	363
421880	Clemson	90.358	94.215	99.079	98.612	123.227	52	80 1 2	801230	363
430060	Huron	27.147	53.463	98.112	100.761	30.886	34	80 430	801230	244
440040	Walker Branch Waters	69.529	71.468	99.962	88.426	66.225	42	80 311	801230	294
441190	Elkmont	27.147	34.903	74.143	101.878	34.772	20	80 812	801230	140
450425	K-Bar	40.556	45.833	95.497	90.314	28.486	38	80 410	801229	263
455350	Victoria	23.546	41.551	90.296	98.757	44.499	37	80 415	801230	259
481300	Horton's Station	69.231	80.769	63.481	91.029	59.885	52	80 1 1	801230	364
491410	Olympic National Par	48.476	60.111	76.875	92.513	195.019	32	80 520	801230	224
513700	Spooner	44.875	52.632	85.488	89.245	57.402	30	80 6 3	801230	210
520860	Yellowstone National	40.608	47.790	92.128	99.291	24.675	30	80 6 5	81 1 1	209
530190	Samoa	54.017	54.017	100.000	86.907	189.813	32	80 520	801230	224
1980 Averages 82 sites		53.881	61.861	92.053	92.550					
1980 Medians 82 sites		51.186	62.700	98.116	93.329					
1980 Number of sites passed		24	17	76	80					
1980 Number of sites failed		58	65	6	2					

1980 15 sites passed all criteria

1980 67 sites failed at least one criteria

1981 Annual Summary Criteria for Weighted Averages.

Dates include weeks beginning 4 JAN 1981 through 28 DEC 1981

ANNUAL SUMMARY CRITERIA

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
020390	Denali (McKinley) Na	76.860	98.072	96.015	96.072	41.932	52	801230	811229	363
030620	Organ Pipe Cactus Na	94.215	100.000	99.175	96.756	18.465	52	801230	811229	363
042700	Fayetteville	90.634	100.000	99.691	99.257	106.629	52	801230	811229	363
053460	Bishop	74.931	98.072	78.073	102.957	11.291	52	801230	811229	363
054540	Hopland	96.143	100.000	95.506	97.277	110.794	52	801230	811229	363
057550	Sequoia National Par	76.923	92.308	82.687	113.364	64.043	52	801230	811230	364
060060	Alamosa	82.645	100.000	99.049	93.062	22.695	52	801230	811229	363
061560	Sand Spring	87.052	98.072	99.666	89.934	41.725	52	801230	811229	363
061910	Rocky Mountain Natio	77.135	100.000	80.805	90.798	33.401	52	801230	811229	363
062120	Manitou	84.848	100.000	74.676	97.407	39.969	52	801230	811229	363
062220	Pawnee	88.430	100.000	92.130	94.252	34.380	52	801230	811229	363
100360	Bradford Forest	84.573	100.000	83.720	91.209	89.562	52	801230	811220	363
114140	Georgia Station	86.501	100.000	93.308	101.180	97.373	52	801230	811229	363
120080	Mauna Loa	82.645	100.000	94.410	97.084	28.840	52	801230	811229	363
141160	Bondville	90.358	100.000	97.851	97.299	100.482	52	801230	811229	363
141980	Argonne	86.777	100.000	96.454	97.064	93.116	52	801230	811229	363
143580	SIU	88.705	100.000	94.024	95.216	105.412	52	801230	811229	363
146340	Dixon Springs Agricu	86.777	100.000	85.889	93.475	113.029	52	801230	811229	363
200045	Caribou	86.501	95.868	91.965	92.128	118.541	52	801230	811229	363
200277	Bridgton	88.430	99.725	94.159	99.026	108.012	52	801230	811229	363
200935	Greenville Station	90.634	100.000	77.289	91.842	113.084	55	801230	811229	363
232660	Kellogg Biological S	86.777	100.000	97.033	93.675	84.100	52	801230	811229	363
241660	Marcell Experimental	94.215	100.000	99.788	89.685	77.651	52	801230	811229	363
242720	Lamberton	84.573	100.000	96.774	83.211	54.315	52	801230	811229	363
251460	Meridian	86.501	100.000	94.462	88.383	106.185	52	801230	811229	363
281520	Mead	88.430	100.000	92.682	95.686	71.805	52	801230	811229	363
300240	Hubbard Brook	100.000	100.000	100.000	96.133	151.488	52	801230	811229	363
330860	Aurora Research Farm	84.573	100.000	86.745	90.236	95.250	52	801230	811229	363
331000	Chautauqua	96.143	98.072	99.259	93.601	102.837	52	801230	811229	363
331220	Knobit	88.430	100.000	77.583	99.838	96.292	52	801230	811229	363
335140	Stilwell Lake	90.358	100.000	91.734	85.879	117.676	52	801230	811229	363
340320	Lewiston	96.143	100.000	99.392	105.130	79.439	52	801230	811229	363
341180	Research Triangle In	88.705	100.000	95.314	96.572	90.792	52	801230	811229	363
342500	Coweeta	96.143	100.000	91.882	93.737	138.301	52	801230	811229	363
343310	Research Triangle Pa	94.215	100.000	99.961	87.032	97.571	52	801230	811229	363
343460	Piedmont Research St	90.358	100.000	99.060	97.719	99.258	52	801230	811229	363
343560	Clinton Crops Resear	92.286	100.000	99.439	94.452	113.018	52	801230	811229	363
344160	Finley (a)	86.501	100.000	95.323	94.489	76.554	52	801230	811229	363
361760	Delaware	88.430	98.072	99.840	111.498	78.832	52	801230	811229	363
364900	Caldwell	96.143	100.000	99.846	101.285	90.649	52	801230	811229	363
367160	Wooster	90.358	100.000	91.309	99.358	82.043	52	801230	811229	363
380200	Alsea Guard Ranger S	90.358	100.000	85.920	100.126	179.679	52	801230	811229	363
380201	Schmidt Farm	94.215	95.317	94.320	98.094	86.592	52	801230	811229	363
381020	H. J. Andrews Experi	88.430	100.000	98.928	97.308	245.175	52	801230	811229	363
394200	Leading Ridge	88.430	100.000	96.562	89.301	96.404	52	801230	811229	363
440040	Walker Branch Waters	94.215	100.000	93.339	103.402	95.333	52	801230	811229	363

1981 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
441190	Elkmont	82.645	100.000	90.439	101.607	142.139	52	801230	811229	363
450425	K-Bar	90.385	100.000	99.822	99.042	42.477	52	801229	811229	364
491410	Olympic National Par	88.430	100.000	81.955	91.490	368.517	52	801230	811229	363
501860	Parsons	98.072	100.000	99.900	94.010	129.404	52	801230	811229	363
030180	Tombstone	44.475	54.144	74.432	95.161	27.471	35	801230	81 9 1	244
030360	Oliver Knoll	31.198	35.097	71.063	92.142	4.433	18	81 825	811229	126
030370	Grand Canyon Nationa	29.248	37.047	62.541	95.644	14.254	20	81 811	811229	140
058500	Channel Islands Nati	53.444	79.890	38.533	99.134	22.481	52	801230	811229	363
058840	Davis Site	55.647	57.576	99.969	100.148	40.360	52	801230	811229	363
058850	Yosemite National Pa	0.	5.850	0.	-1.000	14.478	3	8112 8	811229	21
061530	Mesa Verde National	54.596	68.245	93.902	96.002	30.403	35	81 428	811229	245
100020	Austin-Cary Forest	50.000	53.867	99.275	93.207	47.256	28	801230	81 714	195
101190	Everglades National	69.421	99.725	53.265	97.010	149.762	53	801230	811229	363
130340	Craters of the Moon	79.339	98.072	72.183	86.232	48.484	52	801230	811229	363
141800	NIARC	50.696	60.446	98.938	98.424	54.940	31	81 526	811229	217
144740	Salem	36.639	96.694	23.089	91.255	87.994	53	801230	811229	363
153420	Indiana Dunes Nation	13.260	18.785	84.146	49.375	8.091	11	801230	81 317	76
153421	Indiana Dunes Nation	74.095	77.437	99.975	95.060	100.531	41	81 319	811229	285
200010	Acadia National Park	67.403	84.807	93.694	98.645	95.451	44	801230	8111 3	307
200011	Acadia National Park	11.699	15.599	78.184	95.796	30.969	8	8111 3	811229	56
220155	NACL	3.900	3.900	100.000	65.475	7.620	2	811215	811229	14
230920	Douglas Lake	63.636	98.347	80.374	96.855	65.946	52	801230	811229	363
232240	Houghton	49.862	61.433	77.401	86.913	41.250	52	801230	811229	363
232570	Isle Royale National	30.854	34.711	98.962	98.600	24.476	52	801230	811229	363
235340	Wellston	61.433	100.000	54.086	85.129	77.724	52	801230	811229	363
241840	Fernberg	73.278	98.072	77.660	87.804	67.023	52	801230	811229	363
260380	Ashland Wildlife Are	15.599	19.499	90.076	94.740	14.719	10	811020	811229	70
260560	University Forest	13.649	17.549	99.802	94.590	12.855	9	811027	811229	63
270570	Glacier Fire Weather	32.782	96.419	28.217	98.802	78.172	52	801230	811229	363
312980	Princeton	44.751	51.934	99.774	96.866	50.450	27	801230	81 7 7	188
312981	Washington Crossing	37.047	38.997	99.793	90.740	36.753	21	81 8 4	811229	147
332020	Huntington Wildlife	77.135	100.000	73.839	92.874	102.237	52	801230	811229	363
335240	Bennett Bridge	69.146	100.000	73.214	91.337	129.154	52	801230	811229	363
336500	Jasper	61.708	100.000	78.327	99.935	71.990	52	801230	811229	363
350700	Theodore Roosevelt N	60.446	62.396	99.005	96.166	26.400	34	81 5 5	811229	238
380840	Lost Creek Dam	90.358	98.347	99.918	95.309	93.116	50	801230	811229	363
381120	Vines Hill	50.138	94.490	22.551	75.228	30.524	52	801230	811229	363
381780	Pendleton	77.410	100.000	94.849	89.416	38.937	52	801230	811229	363
392940	Kane Experimental Fo	46.006	100.000	38.091	85.300	131.167	52	801230	811229	363
421880	Clemson	92.562	100.000	99.911	99.816	74.208	52	801230	811229	363
430060	Huron	34.711	98.347	36.686	91.954	40.157	52	801230	811229	363
453800	Forest Seed Center	29.248	37.047	96.082	98.142	39.487	19	81 818	811229	133
455350	Victoria	68.595	100.000	93.553	98.910	113.652	53	801230	811229	363
460280	Cedar Mountain	17.270	19.499	75.118	19.031	13.271	10	81 511	811229	232
470100	Bennington	58.496	68.245	90.087	98.930	73.902	37	81 428	811229	245
481300	Horton's Station	55.923	96.143	67.235	102.684	83.009	52	801230	811229	363
482890	Big Meadows	35.097	62.396	71.167	99.112	91.091	33	81 512	811229	231
513640	Trout Lake	76.584	100.000	73.897	91.760	72.548	52	801230	811229	363

1981 Annual Summary Criteria (Continued)										
NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
513700	Spooner	73.003	93.939	88.534	89.789	76.557	52	801230	811229	363
520829	Newcastle	31.198	38.997	91.433	95.592	10.382	20	81 811	811229	140
520860	Yellowstone National	69.613	100.000	90.085	83.050	34.124	52	81 1 1	811229	362
530190	Samoa	82.645	100.000	84.341	94.696	312.396	52	801230	811229	363
1981 Averages	98 Sites	69.810	94.771	85.137	92.515					
1981 Median	98 Sites	80.992	100.000	92.995	95.263					
1981 Number of passing sites		57	72	80	95					
1981 Number of failing sites		41	26	18	3					
1981			50	sites passed all criteria						
1981			48	sites failed at least one criteria						

1982 Annual Summary Criteria for Weighted Averages.

Dates include weeks beginning 4 JAN 1982 through 28 DEC 1982

ANNUAL SUMMARY CRITERIA

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
030360	Oliver Knoll	88.879	100.000	94.234	94.020	35.471	53	82 1 2	83 1 1	371
030620	Organ Pipe Cactus Na	83.019	100.000	75.410	100.385	26.595	53	82 1 2	83 1 1	371
042700	Fayetteville	90.836	100.000	97.686	95.279	142.149	53	82 1 2	83 1 1	371
054200	Tanbark Flat	90.137	97.808	81.195	93.714	95.643	51	82 116	83 1 1	365
054540	Hopland	94.340	100.000	98.475	98.068	118.225	53	82 1 2	83 1 1	371
057550	Sequoia National Par	86.757	100.000	98.712	89.160	203.122	53	82 1 3	83 1 1	370
058840	Davis Site	92.453	100.000	95.577	98.880	82.970	53	82 1 2	83 1 1	371
061530	Mesa Verde National	84.906	100.000	92.178	91.879	64.938	53	82 1 2	83 1 1	371
061560	Sand Spring	92.453	100.000	97.165	88.962	37.166	53	82 1 2	83 1 1	371
061910	Rocky Mountain Natio	83.019	100.000	94.163	95.107	36.793	53	82 1 2	83 1 1	371
062120	Manitou	79.245	100.000	82.808	88.548	45.579	53	82 1 2	83 1 1	371
062220	Pawnee	84.906	100.000	98.252	96.932	41.414	53	82 1 2	83 1 1	371
100360	Bradford Forest	88.679	100.000	94.017	85.774	150.418	53	82 1 2	83 1 1	371
101190	Everglades National	88.472	100.000	83.309	99.010	161.771	54	82 1 2	83 1 2	373
114140	Georgia Station	94.340	100.000	98.872	98.068	137.364	53	82 1 2	83 1 1	371
120080	Mauna Loa	90.566	100.000	97.380	94.679	117.753	53	82 1 2	83 1 1	371
141160	Bondville	88.679	100.000	96.826	96.341	88.822	53	82 1 2	83 1 1	371
141800	NIARC	86.792	100.000	98.948	93.828	95.357	53	82 1 2	83 1 1	371
141980	Argonne	77.089	98.113	82.041	92.123	106.782	53	82 1 2	83 1 1	371
143580	SIU	94.340	100.000	99.971	98.512	130.189	53	82 1 2	83 1 1	371
144740	Salem	94.340	98.113	99.076	102.128	107.441	53	82 1 2	83 1 1	371
146340	Dixon Springs Agricu	98.113	100.000	99.834	90.053	152.678	53	82 1 2	83 1 1	371
153421	Indiana Dunes Nation	90.566	96.226	99.871	82.809	108.574	53	82 1 2	83 1 1	371
200045	Caribou	84.906	100.000	91.610	89.613	94.607	53	82 1 2	83 1 1	371
200935	Greenville Station	94.340	100.000	90.696	85.777	85.585	53	82 1 2	83 1 1	371
221325	East	86.575	92.055	99.709	98.543	96.141	48	82 2 6	83 1 1	365
230920	Douglas Lake	83.558	98.363	87.797	93.229	87.516	53	82 1 2	83 1 1	371
232660	Kellogg Biological S	77.358	98.113	81.752	91.807	85.187	53	82 1 2	83 1 1	371
241660	Marcell Experimental	90.566	100.000	98.851	92.391	81.739	53	82 1 2	83 1 1	371
241840	Fernberg	88.679	100.000	88.144	90.125	78.844	53	82 1 2	83 1 1	371
242720	Lamberton	94.247	100.000	98.326	88.504	77.368	52	82 1 2	821225	365
251460	Meridian	84.906	100.000	85.750	86.200	165.050	53	82 1 2	83 1 1	371
260380	Ashland Wildlife Are	97.844	100.000	99.067	97.436	125.184	53	82 1 2	83 1 1	371
260560	University Forest	84.906	100.000	90.328	95.122	135.759	53	82 1 2	83 1 1	371
270570	Glacier Fire Weather	94.340	98.113	95.729	84.697	91.890	53	82 1 2	83 1 1	371
281520	Mead	86.575	100.000	97.560	98.462	95.550	52	82 1 2	821225	365
300240	Hubbard Brook	84.906	100.000	90.450	91.093	101.601	53	82 1 2	83 1 1	371
330860	Aurora Research Farm	92.329	100.000	98.071	88.380	74.359	52	82 1 2	821225	365
331000	Chautauqua	88.679	100.000	98.070	87.593	95.647	53	82 1 2	83 1 1	371
331220	Knobit	92.453	98.113	90.538	100.043	70.728	53	82 1 2	83 1 1	371
332020	Huntington Wildlife	79.245	100.000	81.931	95.607	103.740	53	82 1 2	83 1 1	371
335140	Stilwell Lake	90.836	100.000	99.913	93.109	115.666	53	82 1 2	83 1 1	371
336500	Jasper	79.245	100.000	78.297	95.834	75.936	53	82 1 2	83 1 1	371
340320	Lewiston	100.000	100.000	100.000	103.247	116.357	53	82 1 2	83 1 1	371
341189	Research Triangle In	86.792	100.000	93.751	100.738	139.414	53	82 1 2	83 1 1	371
342500	Coweeta	94.340	100.000	96.855	97.139	182.535	53	82 1 2	83 1 1	371

1982 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
343310	Research Triangle Pa	90.566	100.000	99.517	89.682	149.770	53	82 1 2	83 1 1	371
343480	Piedmont Research St	94.340	100.000	98.882	96.033	109.144	53	82 1 2	83 1 1	371
344160	Finley (a)	79.245	100.000	78.373	94.203	117.677	53	82 1 2	83 1 1	371
350700	Theodore Roosevelt N	77.358	100.000	87.874	88.454	54.254	53	82 1 2	83 1 1	371
361760	Delaware	94.340	100.000	98.322	102.507	81.416	53	82 1 2	83 1 1	371
364900	Caldwell	92.722	100.000	99.947	98.852	96.244	53	82 1 2	83 1 1	371
367160	Wooster	85.366	100.000	87.800	98.290	87.620	53	82 1 3	83 1 1	369
394200	Leading Ridge	98.113	100.000	99.951	90.131	104.066	53	82 1 2	83 1 1	371
440040	Walker Branch Waters	94.340	100.000	94.213	95.758	145.279	53	82 1 2	83 1 1	371
441190	Elkmont	83.019	98.113	81.668	100.959	153.312	53	82 1 2	83 1 1	371
450425	K-Bar	84.906	100.000	84.724	91.163	37.491	53	82 1 2	83 1 1	371
453900	Forest Seed Center	81.132	100.000	81.560	97.297	127.271	53	82 1 2	83 1 1	371
455350	Victoria	75.472	100.000	99.320	100.095	84.038	53	82 1 2	83 1 1	371
470100	Bennington	83.019	100.000	80.497	98.056	86.872	53	82 1 2	83 1 1	371
491410	Olympic National Par	88.679	100.000	80.582	97.521	366.445	54	82 1 2	83 1 1	371
501860	Parsons	100.000	100.000	100.000	92.425	151.564	53	82 1 2	83 1 1	371
513640	Trout Lake	81.132	100.000	82.441	90.344	104.314	53	82 1 2	83 1 0	371
513700	Spooner	81.132	100.000	86.347	86.305	84.000	53	82 1 2	83 1 1	371
520820	Newcastle	88.679	100.000	95.558	88.841	46.592	53	82 1 2	83 1 1	371
20390	Denali (McKinley) Na	68.194	96.226	73.527	81.908	35.971	53	82 1 2	83 1 1	371
30370	Grand Canyon Nationa	83.019	100.000	97.225	64.863	63.499	53	82 1 2	83 1 1	371
40260	Warren 2WSW	57.534	61.370	98.017	93.584	109.524	32	82 529	83 1 1	365
41620	Buffalo River	47.945	47.945	100.000	96.979	68.974	25	82 717	83 1 1	365
53480	Bishop	36.538	46.154	94.618	103.344	10.630	25	82 1 2	82 619	364
58500	Channel Islands Nati	5.495	10.989	93.142	89.743	5.250	6	82 1 2	82 214	364
58850	Yosemite National Pa	75.472	100.000	71.337	94.177	212.416	53	82 1 2	83 1 1	371
60060	Alamosa	66.038	81.132	79.693	81.899	12.509	53	82 1 2	83 1 1	371
130340	Craters of the Moon	73.585	100.000	63.895	85.396	57.511	53	82 1 2	83 1 1	371
130480	Headquarters	30.411	41.918	67.465	99.669	46.862	24	82 724	83 1 1	365
154100	Purdue University Ag	46.027	47.945	99.971	102.900	44.176	25	82 717	83 1 1	365
173120	Konza Prairie	32.603	38.356	99.842	95.603	24.040	20	82 821	83 1 1	365
190620	Hill Farm Research S	3.836	13.425	35.381	96.553	48.387	7	821120	83 1 1	365
191260	Iberia Research Stat	9.589	13.425	100.000	-1.000	19.799	7	821120	83 1 1	365
200011	Acadia National Park	49.589	100.000	46.967	99.376	122.370	52	82 1 2	821225	365
200277	Bridgton	66.038	100.000	61.671	94.594	84.162	53	82 1 2	83 1 1	371
220155	NACL	92.453	100.000	96.187	76.289	134.122	53	82 1 2	83 1 1	371
220815	Cadwell	66.849	82.192	88.919	96.440	102.706	44	82 3 8	83 1 1	365
232240	Houghton	56.604	64.151	83.161	81.200	53.881	53	82 1 2	83 1 1	371
232570	Isle Royale National	35.580	37.736	97.426	101.513	33.561	53	82 1 2	83 1 1	371
235340	Wellston	62.264	100.000	59.062	87.279	101.003	53	82 1 2	83 1 1	371
271340	Give Out Morgan	21.096	30.685	92.025	67.753	4.937	16	82 918	83 1 1	365
312981	Washington Crossing	66.038	100.000	72.227	97.179	100.551	53	82 1 2	83 1 1	371
320720	Bandelier	34.521	53.699	54.455	92.435	35.544	28	82 626	83 1 1	365
320980	CUBA	64.932	87.945	77.654	78.254	26.970	48	82 2 6	83 1 1	365
335240	Bennett Bridge	67.925	96.226	71.783	98.808	103.858	53	82 1 2	83 1 1	371
343560	Clinton Crops Resear	73.585	100.000	73.793	94.619	112.522	53	82 1 2	83 1 1	371
380200	Alsea Guard Ranger S	73.585	96.226	73.742	98.757	183.794	53	82 1 2	83 1 1	371
380201	Schmidt Farm	81.132	98.679	95.900	96.152	101.207	53	82 1 2	83 1 1	371

1982 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
380260	Bull Run	34.521	47.945	60.105	88.057	90.497	25	82 717	83 1 1	365
380840	Lost Creek Dam	65.499	100.000	70.759	94.915	95.127	53	82 1 2	83 1 1	371
381020	H. J. Andrews Experi	72.581	100.000	76.752	89.906	245.642	53	82 1 2	83 1 1	372
381120	Vines Hill	82.345	98.113	0.	-1.000	24.308	53	82 1 2	83 1 1	371
381780	Pendleton	30.769	46.154	87.556	88.763	12.446	24	82 1 2	82 612	364
392940	Kane Experimental Fo	66.038	100.000	72.900	91.033	118.184	53	82 1 2	83 1 1	371
421880	Clemson	98.113	100.000	99.990	100.842	125.646	53	82 1 2	83 1 1	371
430060	Huron	55.849	100.000	46.348	88.413	62.752	53	82 1 2	83 1 1	371
452180	Longview	46.027	51.781	99.925	98.276	50.939	27	82 7 3	83 1 1	365
460280	Cedar Mountain	60.377	93.801	80.091	59.342	21.727	53	82 1 2	83 1 1	371
481300	Horton's Station	33.962	97.574	38.019	109.721	83.079	53	82 1 3	83 1 1	371
482890	Big Meadows	56.334	97.844	69.949	91.318	122.664	53	82 1 2	83 1 1	371
512800	Lake Dubay	46.027	51.781	99.480	94.737	43.805	27	82 7 3	83 1 1	365
520680	Pinedale	66.849	93.973	90.006	76.431	34.318	49	82 130	83 1 1	365
520860	Yellowstone National	57.143	100.000	49.270	92.639	57.077	53	82 1 2	83 1 1	371
530190	Samoa	64.151	94.340	56.310	98.455	188.278	53	82 1 2	83 1 1	371
1982 Averages 110 Sites		74.082	89.844	85.719	90.964					
1982 Median 110 Sites		83.019	100.000	91.818	93.924					
1982 Number of passing sites		70	89	88	106					
1982 Number of failing sites		40	21	22	4					

1982 65 sites passed all criteria

1982 45 sites failed at least one criteria

1983 Annual Summary Criteria for Weighted Averages.

Dates include weeks beginning 4 JAN 1983 through 28 DEC 1983

ANNUAL SUMMARY CRITERIA

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
030360	Oliver Knoll	76.503	100.000	83.831	97.894	46.479	52	83 1 1	831225	366
030370	Grand Canyon Nationa	88.679	100.000	99.583	89.360	51.793	53	83 1 1	84 1 0	371
030620	Organ Pipe Cactus Na	92.453	100.000	99.268	93.719	46.848	53	83 1 1	84 1 0	371
040260	Warren 2WSW	92.453	100.000	93.669	98.655	132.398	53	83 1 1	84 1 0	371
041620	Buffalo River	77.358	100.000	91.762	100.526	107.940	53	83 1 1	84 1 0	371
042700	Fayetteville	90.566	98.113	98.430	88.175	90.578	53	83 1 1	84 1 0	371
054200	Tanbark Flat	92.453	100.000	98.728	91.786	181.771	53	83 1 1	84 1 0	371
054540	Hopland	100.000	100.000	100.000	98.982	182.765	53	83 1 1	84 1 0	371
057550	Sequoia National Par	84.636	96.226	93.126	100.805	148.332	53	83 1 1	84 1 0	371
058840	Davis Site	94.340	100.000	99.834	98.113	91.693	53	83 1 1	84 1 0	371
058850	Yosemite National Pa	95.095	100.000	90.227	99.237	230.019	53	83 1 1	831225	367
061530	Mesa Verde National	81.132	100.000	94.393	81.062	57.291	53	83 1 1	84 1 0	371
061560	Sand Spring	86.792	100.000	82.941	96.354	42.736	53	83 1 1	84 1 0	371
061910	Rocky Mountain Natio	94.340	100.000	92.694	93.274	45.344	54	83 1 1	84 1 0	371
062120	Manitou	86.792	100.000	92.755	81.013	48.718	53	83 1 1	84 1 0	371
062220	Pawnee	84.906	100.000	97.514	85.604	37.275	53	83 1 1	84 1 0	371
100360	Bradford Forest	84.906	98.113	90.557	94.128	161.926	53	83 1 1	84 1 0	371
114140	Georgia Station	84.906	100.000	91.778	95.974	128.054	53	83 1 1	84 1 0	371
120080	Mauna Loa	90.566	100.000	99.422	98.512	15.252	53	83 1 1	84 1 0	371
141160	Bondville	77.358	100.000	83.267	93.895	98.086	53	83 1 1	84 1 0	371
141800	NIARC	86.792	100.000	95.844	97.555	100.018	53	83 1 1	84 1 0	371
141980	Argonne	81.402	98.113	89.095	101.831	112.614	53	83 1 1	84 1 0	371
143580	SIU	96.226	100.000	99.739	99.561	116.895	53	83 1 1	84 1 0	371
144740	Salem	86.792	100.000	99.859	105.531	102.634	53	83 1 1	84 1 0	371
146340	Dixon Springs Agricu	96.226	100.000	99.957	88.923	146.521	53	83 1 1	84 1 0	371
153421	Indiana Dunes Nation	94.340	98.113	98.954	89.063	93.453	53	83 1 1	84 1 0	371
154100	Purdue University Ag	90.566	100.000	96.391	97.005	85.142	53	83 1 1	84 1 0	371
173120	Konza Prairie	86.792	100.000	94.746	97.508	75.906	53	83 1 1	84 1 0	371
191260	Iberia Research Stat	78.437	98.113	87.843	99.360	172.793	53	83 1 1	84 1 0	371
200045	Caribou	76.011	100.000	87.014	94.233	117.551	53	83 1 1	84 1 0	371
200935	Greenville Station	86.792	100.000	97.841	89.370	145.274	53	83 1 1	84 1 0	371
221325	East	94.340	100.000	97.103	96.955	135.696	53	83 1 1	84 1 0	371
230920	Douglas Lake	81.402	100.000	90.158	94.693	90.972	53	83 1 1	84 1 0	371
232660	Kellogg Biological S	77.358	97.574	86.573	84.263	94.488	53	83 1 1	84 1 0	371
235340	Wellston	94.340	100.000	97.176	88.172	98.042	53	83 1 1	84 1 0	371
241660	Marcell Experimental	79.245	100.000	89.616	92.256	70.318	53	83 1 1	84 1 0	371
241840	Fernberg	92.453	100.000	93.895	84.058	88.933	53	83 1 1	84 1 0	371
242720	Lamberton	81.301	100.000	96.869	81.369	63.508	53	83 1 1	831230	369
251460	Meridian	86.792	100.000	89.965	86.774	190.149	53	83 1 1	84 1 0	371
260380	Ashland Wildlife Are	98.113	100.000	98.724	93.722	103.506	53	83 1 1	84 1 0	371
260560	University Forest	90.566	100.000	98.520	95.910	114.159	53	83 1 1	84 1 0	371
270570	Glacier Fire Weather	88.679	96.226	98.825	84.576	84.250	53	83 1 1	84 1 0	371
271340	Give Out Morgan	74.933	100.000	78.799	79.381	17.734	53	83 1 1	84 1 0	371
281520	Mead	86.757	100.000	95.478	88.946	66.002	53	83 1 1	84 1 0	370
300240	Hubbard Brook	86.792	100.000	91.077	95.295	130.935	53	83 1 1	84 1 0	371
312981	Washington Crossing	83.019	100.000	89.087	97.234	142.163	53	83 1 1	84 1 0	371

1983 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
320720	Bandelier	93.019	100.000	90.697	91.520	87.058	54	83 1 1	84 1 0	371
320950	CUBA	79.245	100.000	80.797	88.373	56.043	53	63 1 1	84 1 0	371
330860	Aurora Research Farm	94.595	100.000	99.343	88.651	79.282	53	83 1 1	84 1 0	370
331000	Chautauqua	90.566	100.000	96.853	94.456	104.532	53	83 1 1	84 1 0	371
332020	Huntington Wildlife	84.906	100.000	89.682	99.342	119.027	53	83 1 1	84 1 0	371
335140	Stilwell Lake	88.679	100.000	90.262	93.284	185.077	53	83 1 1	84 1 0	371
335240	Bennett Bridge	92.453	98.113	97.343	88.692	145.786	53	83 1 1	84 1 0	371
336500	Jasper	90.566	100.000	96.807	95.317	67.171	53	83 1 1	84 1 0	371
340320	Lewiston	96.226	100.000	93.843	95.446	109.750	53	83 1 1	84 1 0	371
342500	Coweeta	77.358	100.000	88.473	98.530	201.515	53	83 1 1	84 1 0	371
343460	Piedmont Research St	96.226	100.000	99.920	97.204	111.542	53	83 1 1	84 1 0	371
343500	Clinton Crops Resear	90.566	98.113	93.686	97.421	131.546	53	83 1 1	84 1 0	371
344160	Finley (a)	86.792	98.113	81.227	89.422	119.670	53	83 1 1	84 1 0	371
361760	Delaware	94.340	100.000	99.689	100.105	87.197	53	83 1 1	84 1 0	371
364900	Caldwell	94.340	100.000	94.778	100.137	103.364	53	83 1 1	84 1 0	371
367160	Wooster	92.453	100.000	93.156	98.078	85.918	53	83 1 1	84 1 0	371
372580	Clayton Lake	84.615	92.308	95.229	96.298	99.278	48	83 2 5	84 1 0	364
380840	Lost Creek Dam	87.945	93.699	90.508	100.540	97.934	49	83 1 1	8312 2	365
392940	Kane Experimental Fo	81.132	100.000	86.126	92.721	128.054	53	83 1 1	84 1 0	371
394200	Leading Ridge	94.340	100.000	97.996	89.955	115.987	53	83 1 1	84 1 0	371
440040	Walker Branch Waters	94.340	100.000	97.100	102.036	116.041	53	83 1 1	84 1 0	371
450425	K-Bar	90.566	100.000	98.180	101.183	28.627	53	83 1 1	84 1 0	371
452180	Longview	84.906	100.000	97.954	99.213	111.734	53	83 1 1	84 1 0	371
453800	Forest Seed Center	86.792	100.000	80.618	98.486	134.060	54	83 1 1	84 1 0	371
470100	Bennington	86.792	94.340	96.033	89.553	115.583	53	83 1 1	84 1 0	371
501860	Parsons	98.113	100.000	98.658	91.022	123.010	53	83 1 1	84 1 0	371
512900	Lake Dubay	86.792	97.574	95.700	92.980	64.093	53	83 1 1	84 1 0	371
513640	Trout Lake	79.301	100.000	84.685	95.240	85.914	53	83 1 0	84 1 0	372
513700	Spooner	81.132	100.000	96.524	86.482	91.339	53	83 1 1	84 1 0	371
520820	Newcastle	94.340	98.113	99.744	88.219	34.590	54	33 1 1	84 1 0	371
530190	Samoa	90.566	100.000	97.511	100.250	176.029	53	83 1 1	84 1 0	371
011000	Blackbelt Substation	34.341	34.341	100.000	99.513	50.065	18	83 2 3	84 1 0	364
020590	Denali (McKinley) Na	67.655	97.844	93.686	63.795	42.790	53	83 1 1	84 1 0	371
056820	Palomar Mountain	75.000	80.769	91.391	99.211	101.051	42	83 319	84 1 0	364
058501	Chuchupate Ranger St	28.846	42.308	82.542	87.675	21.387	22	83 8 6	84 1 0	364
060050	Alamosa	71.698	100.000	68.631	85.176	18.504	53	83 1 1	84 1 0	371
060190	Las Animas Fish Hatc	17.308	25.000	39.716	98.918	1.917	13	8310 8	84 1 0	364
061911	Loch Vale	52.692	38.462	90.488	48.819	34.650	20	83 820	84 1 0	364
100380	CIFANT	28.846	42.308	66.219	100.808	68.340	22	83 8 6	84 1 0	364
101190	Everglades National	67.925	100.000	59.393	94.581	164.416	54	83 1 2	84 1 0	371
104100	Verna Well Field	13.462	35.989	53.404	83.325	52.414	19	83 828	84 1 0	364
112040	Bellville	67.308	69.231	99.975	99.514	51.079	36	83 420	84 1 0	364
115000	Tifton, ARS	23.077	25.000	97.089	90.165	33.146	13	8310 8	84 1 0	364
130340	Craters of the Moon	62.264	100.000	74.372	90.664	49.298	53	83 1 1	84 1 0	371
130480	Headquarters	65.591	97.849	70.367	92.537	113.202	53	83 1 1	84 1 0	372
131180	Reynolds Creek	6.027	11.781	33.242	52.865	9.855	6	831128	84 1 0	365
141161	Bondville Intercompa	25.000	28.846	96.757	83.594	38.409	15	83 924	84 1 0	364
152020	Huntington Reservoir	24.725	36.813	74.820	65.600	40.213	19	83 826	84 1 0	364

1983 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
180360	Perryville	5.769	9.615	85.948	98.257	8.185	5	8312 3	84 1 0	364
182260	Lilley Cornett Woods	28.846	32.692	92.726	94.790	21.996	17	83 910	84 1 0	364
183560	Clark State Fish Hat	25.000	34.615	85.164	97.919	28.334	18	83 9 3	84 1 0	364
190620	Hill Farm Research S	69.542	97.305	66.560	98.022	120.355	53	83 1 1	84 1 0	371
193060	Southeast Research S	67.033	94.231	73.521	98.487	185.454	50	83 122	84 1 0	364
200011	Acadia National Park	70.000	98.649	7[illegible].928	91.654	193.587	53	83 1 1	84 1 0	370
200277	Bridgton	85.019	86.792	95.695	95.098	134.227	53	83 1 1	84 1 0	371
211320	Wye	76.923	82.692	96.730	97.069	113.3[illegible]4	43	83 312	84 1 0	364
220155	NACL	64.151	100.000	72.927	88.902	160.949	53	83 1 1	84 1 0	371
220815	Cadwell	50.943	100.000	40.111	85.067	151.220	53	83 1 1	84 1 0	371
232240	Houghton	13.425	13.425	100.000	81.803	6.121	7	83 1 1	83 212	365
232241	Chassell	79.121	84.890	95.202	92.389	93.155	46	83 219	84 1 0	364
232570	Isle Royale National	35.849	41.509	85.320	93.295	53.206	53	83 1 1	84 1 0	371
242360	Camp Ripley	3.846	21.154	17.616	91.091	12.256	11	831022	84 1 0	364
270560	St. Mary Ranger Stat	63.187	88.187	82.395	84.431	33.910	49	83 129	84 1 0	364
331220	Knobit	73.854	100.000	82.063	94.368	121.426	53	83 1 1	84 1 0	371
335141	West Point	30.769	30.769	100.000	96.210	63.321	16	83 917	84 1 0	364
336840	Biscuit Brook	15.877	22.006	76.080	80.697	38.227	11	831014	831225	359
343310	Research Triangle Pa	15.342	17.260	99.948	90.187	24.626	9	83 1 1	83 226	365
343600	Jordan Creek	17.308	21.154	96.971	99.110	38.976	11	831022	84 1 0	364
350700	Theodore Roosevelt N	70.081	98.113	88.689	97.054	26.155	53	83 1 1	84 1 0	371
350880	Icelandic State Park	7.692	19.231	10.137	38.647	1.756	10	831029	84 1 0	364
351180	Woodworth	5.769	9.615	0.	-1.000	0.762	5	8312 3	84 1 0	364
370060	Salt Plains National	1.923	3.846	0.	-1.000	0.007	3	831217	84 1 0	364
371740	Great Plains Apiarie	61.538	76.099	90.055	101.568	91.481	40	83 4 2	84 1 0	364
380200	Alsea Guard Ranger S	70.245	100.000	64.494	97.072	213.074	53	83 1 1	84 1 0	371
380201	Schmidt Farm	28.767	32.603	95.217	-1.000	61.108	17	83 1 1	83 423	365
380202	Hyslop	59.615	69.231	95.010	91.888	62.350	36	83 430	84 1 0	364
380260	Bull Run	79.245	100.000	70.661	96.506	202.452	53	83 1 1	84 1 0	371
386980	Silver Lake Ranger S	26.923	36.538	46.941	85.674	18.668	19	83 827	84 1 0	364
381020	H. J. Andrews Experi	71.968	100.000	71.213	95.992	258.657	53	83 1 1	84 1 0	371
381120	Vines Hill	66.038	99.191	85.906	99.263	38.493	54	83 1 1	84 1 0	371
391520	Penn State	48.077	57.692	93.424	98.033	58.509	30	83 611	84 1 0	364
391521	Penn State Intercomp	23.077	25.000	96.553	88.103	33.883	13	8310 8	84 1 0	364
421880	Clemson	89.891	100.000	95.546	97.167	123.189	52	83 1 1	831225	366
430060	Huron	36.438	70.959	71.434	82.747	37.213	38	83 1 1	83 917	365
430061	Huron Well Field	1.923	9.615	0.	-1.000	0.710	5	8312 3	84 1 0	364
430880	Cottonwood	19.231	23.077	93.049	82.653	5.841	12	831015	84 1 0	364
441190	Elkmont	72.951	97.814	67.772	95.515	143.955	52	83 1 1	831225	366
455350	Victoria	81.132	100.000	74.090	99.654	107.784	54	83 1 1	84 1 0	371
455640	LBJ National Grassla	25.000	28.846	99.665	93.504	22.656	15	83 924	84 1 0	364
460120	Logan	5.769	7.692	92.980	16.219	6.154	4	831210	84 1 0	364
460280	Cedar Mountain	32.075	94.340	28.667	70.162	26.984	53	83 1 1	84 1 0	371
481300	Horton's Station	71.698	100.000	85.716	94.061	90.882	53	83 1 1	84 1 0	371
482890	Big Meadows	67.925	100.000	69.320	96.627	183.419	53	83 1 1	84 1 0	371
491410	Olympic National Par	88.679	100.000	59.032	94.205	405.598	58	83 1 1	84 1 0	371
500460	Babcock State Park	26.923	32.692	74.165	76.459	37.948	17	83 910	84 1 0	364
520680	Pinedale	67.925	100.000	63.139	71.320	43.650	53	83 1 1	84 1 0	371

1983 Annual Summary Criteria (Continued)

NUMBER	STATION	1	2	3	4	PPT	WKS	DATES		DAYS
520860	Yellowstone National	42.049	98.113	42.563	101.706	34.606	53	83 1 1	84 1 0	371
1983 Averages	143 sites	68.027	81.712	84.233	88.631					
1983 Medians	143 sites	79.245	100.000	91.779	94.128					
1983 Number of sites passed		85	101	110	131					
1983 Number of sites failed		58	42	33	12					
	1983		76	sites passed all criteria						
	1983		67	sites failed at least one criteria						

II. Annual Labtype and Screening Category Counts by Year

David S. Bigelow

A. Labtype and Screening Category Code Definitions

Missing Records summarize various categories of data completeness.

SR	Site Records. Number of records reported by the site for this summary period.
PR	Precipitation Records. Number of records which have precipitation information.
BS	Bucket Substitutions. Samples whose only valid precipitation measurements come from the Wet/ Dry collector bucket.
NN	No Information. Information was never reported and will never be available for this collection period.

Problem Record codes are a summary of remarks written about a weekly sample by field personnel, the Central Analytical Laboratory (CAL) or the NADP Coordinator's Office.

NS	No Sample. No chemistry data will be reported for this sample. These data have been excluded from the report for various reasons, including extreme contamination, lack of conforming to a definable sample type, leakage, or loss in the mail.
BU	Bulk Sample. A wet side sample that was continuously exposed to both wet and dry fall during the sampling period.
SP	Sample Protocol Problem. Sample does not meet NADP sampling protocol requirements. The sample probably characterizes the individual site adequately but is not suitable for across-site comparisons. Examples of this problem include nonapproved sampling sites, nonapproved sampling equipment, and nonapproved or irregular sampling intervals.
LD	Long Duration Sample. LD indicates any sample left on the collector for multiple sampling periods.
TL8	Time Limit. The sampling interval exceeds eight days.
TL13	Time Limit. The sampling interval exceeds thirteen days.

Lab Type indicates the condition of the sample as it arrived at the Central Analytical Laboratory (CAL).

W	indicates a normal sample.
WA	indicates the sample had to be diluted for analysis; 50 ml of water was added.
T	indicates a trace; dilution was unwarranted.
DA	indicates the bucket arrived dry.
QA	indicates this sample was a Quality Assurance Sample.

B. Tables

NUMBER OF RECORDS BY SITE AND TYPE

Counts include dates with a DATEOFF of less than January 4, 1979

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
058840	Davis Site	11	9	6	5	0	0	0	0	2	2	2	5	0	1	3	0
062120	Manitou	11	10	6	6	0	0	0	0	1	1	1	6	0	0	4	0
100020	Austin-Cary Forest	12	12	8	4	0	0	0	0	0	0	0	6	2	0	4	0
100360	Bradford Forest	12	12	10	2	0	0	0	0	0	0	0	8	0	2	2	0
114140	Georgia Station	13	12	9	4	0	0	0	0	1	1	1	9	0	0	3	0
235340	Wellston	12	11	10	2	0	1	0	0	1	1	1	8	1	1	0	0
241660	Marcell Experimental Forest	25	20	16	10	6	2	0	1	0	0	0	15	0	1	2	0
281520	Mead	23	17	13	17	5	0	0	0	1	1	1	8	2	3	4	0
300240	Hubbard Brook	23	21	21	2	2	0	0	0	0	0	0	20	0	1	0	0
332020	Huntington Wildlife	9	9	9	3	0	0	0	0	0	0	0	8	0	1	0	0
340320	Lewiston	9	8	7	4	1	1	0	0	0	0	0	7	0	0	0	0
342500	Coweeta	25	15	12	14	11	1	0	0	0	0	0	12	0	0	2	0
343460	Piedmont Research Station	11	9	8	3	2	0	0	0	0	0	0	7	0	1	1	0
343560	Clinton Crops Research Station	10	10	10	0	0	0	0	0	0	0	0	9	1	0	0	0
344160	Finley (a)	13	12	10	3	0	0	0	0	1	1	1	10	0	0	1	0
344161	Finley (b)	13	12	10	3	0	0	0	0	1	1	1	10	0	0	1	0
361760	Delaware	13	12	11	8	0	1	0	0	1	1	1	10	0	1	0	0
364900	Caldwell	14	14	14	0	0	0	0	0	0	0	0	14	0	0	0	0
367160	Wooster	14	14	14	0	0	0	0	0	0	0	0	13	0	1	0	0
392940	Kane Experimental Forest	24	15	15	9	9	0	1	0	0	0	0	15	0	0	0	0
481300	Horton's Station	23	14	11	15	9	2	0	0	0	0	0	9	1	1	1	0
501860	Parsons	25	26	26	0	0	0	0	0	0	0	0	25	0	1	0	0
TOTAL ALL SITES (22 sites)		348	291	256	114	45	8	1	1	9	9	9	234	7	15	28	0
RECORD TYPE			SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
PERCENT**			83.6	73.6	32.7	13.8	2.5	0.3	0.3	3.1	3.1	3.1	67.2	2.0	4.3	8.6	0

** computed as a percent of SR (site records)

NUMBER OF RECORDS BY SITE AND TYPE

Counts include dates beginning 4 JAN 1979 through 28 DEC 1979

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
030180	Tombstone	40	19	15	25	20	0	0	0	1	1	1	12	2	1	4	0
054540	Hopland	13	13	11	3	0	0	0	0	0	0	0	9	0	2	2	0
058840	Davis Site	52	36	29	25	15	1	0	0	1	1	1	23	1	4	6	1
061560	Sand Spring	41	40	31	10	0	0	0	0	1	1	1	27	4	0	9	0
062120	Manitou	52	46	29	24	1	0	0	0	5	5	5	23	2	4	15	0
062220	Pawnee	32	31	28	9	0	1	0	0	1	1	1	21	0	6	3	1
100020	Austin-Cary Forest	52	50	45	8	2	0	0	0	0	0	0	36	5	4	5	0
100360	Bradford Forest	52	48	43	10	4	1	0	0	0	0	0	36	2	5	4	0
114140	Georgia Station	52	52	43	11	0	1	1	0	0	0	0	42	0	1	8	0
141160	Bondville	44	43	38	7	0	0	0	0	1	1	1	33	1	4	5	0
143580	SIU	22	22	20	2	0	1	0	0	0	0	0	16	1	3	1	0
146340	Dixon Springs Agriculture Center	48	45	39	11	3	1	0	2	0	1	0	37	1	2	4	0
200935	Greenville Station	6	6	6	5	0	0	3	0	0	0	0	5	0	1	0	0
230920	Douglas Lake	25	26	22	4	0	0	0	0	0	0	0	21	0	1	4	0
232660	Kellogg Biological Station	27	27	25	4	0	1	0	0	0	0	0	20	2	3	1	0
235340	Wellston	53	43	35	19	7	6	6	4	3	5	3	28	3	4	2	0
241660	Marcell Experimental Forest	52	52	49	3	0	2	4	0	0	0	0	44	2	2	2	1
242720	Lamberton	52	51	40	12	0	2	0	0	1	1	1	37	0	3	9	0
281520	Mead	52	52	42	17	0	2	1	0	0	0	0	32	2	8	8	0
300240	Hubbard Brook	52	52	47	5	0	2	2	0	0	0	0	45	0	2	3	0
330860	Aurora Research Farm	37	37	34	4	0	1	0	0	0	1	0	32	2	0	2	0
332020	Huntington Wildlife	52	52	50	4	0	1	0	0	0	0	0	49	1	0	1	0
335140	Stilwell Lake	27	27	23	4	0	3	0	1	0	0	0	23	0	0	1	0
340320	Lewiston	52	52	52	1	0	0	0	0	0	0	0	46	1	5	0	0
342500	Coweeta	52	52	49	4	0	1	0	0	0	0	0	46	1	1	3	1
343460	Piedmont Research Station	52	47	42	11	5	1	0	0	0	0	0	38	0	5	3	0
343560	Clinton Crops Research Station	52	52	40	4	0	0	0	0	0	0	0	43	1	5	3	0
344160	Finley (a)	52	52	48	7	0	0	0	0	0	1	0	42	1	5	4	0
344161	Finley (b)	52	52	39	14	0	8	1	0	0	1	0	37	0	2	5	0
361760	Delaware	52	52	50	9	0	0	0	0	0	0	0	48	0	2	2	0
364900	Caldwell	52	51	47	6	1	0	0	0	0	0	0	43	1	4	3	0
367160	Wooster	52	52	48	6	0	0	0	0	0	0	0	44	2	3	3	0
380200	Alsea Guard Ranger Station	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
380201	Schmidt Farm	1	1	1	0	0	1	0	0	0	1	0	1	0	0	0	0
392940	Kane Experimental Forest	52	52	43	9	0	8	19	0	0	0	0	42	0	1	1	0
394200	Leading Ridge	36	36	33	4	0	1	0	0	0	0	0	31	1	1	2	0
421880	Clemson	41	39	37	5	0	2	0	2	2	3	2	31	0	6	1	0
481300	Horton's Station	52	47	44	46	5	2	0	2	0	1	0	37	6	2	0	0
501860	Parsons	52	52	52	0	0	0	0	0	0	0	0	50	0	2	0	0
TOTAL ALL SITES (39 sites)		1639	1560	1379	354	63	50	37	11	16	25	16	1231	45	104	129	4

RECORD TYPE	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
PERCENT**	95.2	84.1	21.6	3.8	3.1	2.3	0.7	1.0	1.5	1.0	75.1	2.8	6.4	7.8	0.2

** computed as a percent of SR (site records)

NUMBER OF RECORDS BY SITE AND TYPE

Counts include dates beginning 4 JAN 1980 through 28 DEC 1980

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
020390	Denali (McKinley) National Park	28	28	27	2	0	0	0	0	0	0	0	18	4	2	4	0
030180	Tombstone	52	27	13	40	25	2	0	0	0	0	0	12	0	1	12	0
030620	Organ Pipe Cactus National Monument	37	37	18	22	0	2	0	0	0	0	0	8	1	5	22	0
042700	Fayetteville	33	33	22	11	0	1	0	0	0	0	0	20	0	1	11	0
053460	Bishop	36	34	12	25	0	4	1	1	2	3	2	6	2	4	18	0
054540	Hopland	52	52	33	19	0	0	0	0	0	0	0	24	4	5	19	0
057550	Sequoia National Park	25	25	15	11	0	2	0	0	0	0	0	7	0	4	14	0
058500	Channel Islands National Park	23	8	4	20	14	2	0	1	1	1	1	1	1	1	6	0
058840	Davis Site	52	30	21	33	22	2	0	0	0	0	0	15	2	3	7	1
060060	Alamosa	36	36	20	19	0	2	0	1	0	0	0	12	1	3	19	0
061560	Sand Spring	52	52	39	14	0	3	0	0	0	0	0	31	2	3	13	1
061910	Rocky Mountain National Park	31	29	22	11	0	3	0	1	2	2	2	16	1	3	7	0
062120	Manitou	52	48	28	25	1	5	1	0	3	3	3	19	1	3	21	0
062220	Pawnee	52	52	41	24	5	3	0	2	0	1	0	21	4	11	13	1
100020	Austin-Cary Forest	52	45	39	14	3	6	1	1	4	4	4	32	1	3	4	0
100360	Bradford Forest	52	42	35	17	6	4	0	0	4	4	4	28	2	4	3	0
101190	Everglades National Park	28	28	18	11	0	13	0	0	0	0	0	17	0	1	0	0
114140	Georgia Station	52	52	41	11	0	6	0	0	0	0	0	38	1	0	7	2
120080	Mauna Loa	29	29	19	11	0	0	0	0	0	0	0	12	1	2	14	0
130340	Craters of the Moon	18	18	16	7	0	0	0	2	0	2	0	11	2	3	2	0
141160	Bondville	52	52	45	7	0	0	0	0	0	0	0	38	4	1	9	0
141980	Argonne	42	42	37	6	0	2	0	0	0	0	0	33	1	3	3	0
143580	SIU	52	52	42	11	0	6	0	0	0	1	0	34	1	4	8	1
144740	Salem	37	37	32	9	0	3	0	0	0	0	0	23	4	5	2	0
146340	Dixon Springs Agriculture Center	52	52	46	6	0	1	0	0	0	0	0	36	1	11	3	0
153420	Indiana Dunes National Lakeshore	24	23	23	3	1	0	0	0	0	0	0	21	0	2	0	0
200010	Acadia National Park	6	6	6	3	0	0	0	0	0	0	0	6	0	0	0	0
200045	Caribou	37	35	30	7	0	6	0	4	2	4	2	29	1	0	1	0
200277	Bridgton	13	13	11	4	0	2	0	0	0	0	0	10	0	1	0	0
200935	Greenville Station	52	50	41	38	1	8	17	1	1	1	1	36	3	3	0	0
230920	Douglas Lake	52	52	43	9	0	9	2	0	0	0	0	40	2	1	2	0
232240	Houghton	10	10	8	2	0	1	0	1	0	0	0	8	0	0	1	0
232570	Isle Royale National Park	20	9	8	12	10	1	0	0	1	1	1	8	0	0	0	0
232660	Kellogg Biological Station	52	52	43	9	0	5	0	0	0	0	0	38	0	4	5	0
235340	Wellston	52	51	49	4	0	0	9	4	1	3	1	45	3	0	2	1
241660	Marcell Experimental Forest	52	52	43	9	0	5	0	0	0	1	0	36	2	4	5	0
241840	Fernberg	6	6	6	0	0	2	0	0	0	0	0	4	0	2	0	0
242720	Lamberton	52	51	39	17	1	7	0	0	0	0	0	30	1	3	10	2
251460	Meridian	37	37	30	9	0	0	0	3	0	2	0	24	2	4	7	0
270570	Glacier Fire Weather	30	27	25	5	0	0	0	0	3	3	3	23	2	1	2	0
281520	Mead	52	52	37	19	0	7	0	0	0	0	0	25	3	3	14	0
300240	Hubbard Brook	52	52	48	4	0	4	1	0	0	0	0	45	0	2	2	1
312980	Princeton	21	20	17	4	0	3	0	18	1	1	1	17	0	0	0	0
330860	Aurora Research Farm	52	52	47	5	0	3	0	1	0	0	0	42	3	2	2	0
331000	Chautauqua	29	28	27	4	0	2	3	0	1	1	1	25	2	0	0	0
331220	Knobit	52	51	46	10	0	3	4	0	1	1	1	43	1	2	2	0

NUMBER OF RECORDS BY SITE AND TYPE

(1980 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
332020	Huntington Wildlife	52	52	47	8	0	6	4	0	0	0	0	44	1	1	1	1
335140	Stilwell Lake	52	52	44	21	0	7	0	0	0	0	0	39	2	2	2	1
335240	Bennett Bridge	29	25	21	12	0	2	11	0	4	4	4	21	0	0	2	0
336500	Jasper	45	45	42	5	0	1	0	0	0	0	0	38	2	3	1	0
340320	Lewiston	52	52	49	4	0	0	0	0	0	0	0	40	4	5	3	0
341180	Research Triangle Institute	11	7	6	5	4	2	0	0	0	0	0	5	0	0	1	0
342500	Coweeta	52	51	49	4	0	4	0	0	1	1	1	45	0	2	1	1
343310	Research Triangle Park	37	37	30	8	0	3	0	0	0	0	0	25	0	3	5	0
343460	Piedmont Research Station	52	52	50	3	0	1	0	0	0	0	0	39	3	8	1	0
343560	Clinton Crops Research Station	52	52	52	1	0	1	0	0	0	0	0	44	1	5	1	1
344160	Finley (a)	52	52	46	6	0	2	0	0	0	0	0	42	0	3	5	0
344161	Finley (b)	13	13	12	1	0	1	0	0	0	0	0	12	0	0	0	0
361760	Delaware	52	52	50	19	0	2	0	0	0	0	0	45	1	4	0	0
364900	Caldwell	52	52	49	9	0	4	0	2	0	1	0	44	2	2	0	1
367160	Wooster	52	52	50	6	0	2	0	2	0	1	0	44	2	3	0	1
380200	Alsea Guard Ranger Station	52	51	40	14	0	4	0	1	1	2	1	37	1	2	7	0
380201	Schmidt Farm	52	49	39	14	2	1	0	3	1	2	1	35	1	3	8	0
380840	Lost Creek Dam	10	9	9	1	0	0	0	0	1	0	1	8	0	1	0	0
381020	H. J. Andrews Experimental Forest	33	30	24	9	3	0	0	0	0	0	0	19	3	1	7	0
381120	Vines Hill	23	22	15	13	0	4	0	0	0	1	1	10	2	3	6	0
381780	Pendleton	37	34	27	11	2	0	0	4	1	2	1	19	4	4	7	0
392940	Kane Experimental Forest	52	52	43	9	0	10	5	0	0	0	0	40	2	0	0	1
394200	Leading Ridge	52	52	49	5	0	3	0	0	0	0	0	45	2	1	1	0
421880	Clemson	52	52	49	9	0	0	0	0	0	0	0	39	1	6	5	1
430060	Huron	34	31	24	14	0	2	0	3	3	5	3	16	1	6	7	0
440040	Walker Branch Watershed	42	42	37	6	0	3	1	0	0	0	0	31	1	3	3	2
441190	Elkmont	20	20	18	2	0	4	5	0	0	0	0	13	0	3	2	0
450425	K-Bar	38	38	24	15	0	3	0	1	0	0	0	17	4	2	13	0
455350	Victoria	37	31	16	21	4	8	0	2	2	3	2	12	0	3	11	0
481300	Horton's Station	52	46	42	32	6	8	2	0	0	0	0	37	3	1	1	0
491410	Olympic National Park	32	31	29	5	0	1	0	0	2	2	2	25	1	2	1	0
501860	Parsons	52	52	51	2	0	2	0	0	0	0	0	51	0	0	0	0
513640	Trout Lake	49	49	46	13	0	0	0	0	0	0	0	39	4	3	3	0
513700	Spooner	30	30	27	3	0	3	0	0	0	0	0	21	2	3	3	0
520860	Yellowstone National Park	30	30	25	5	0	1	2	2	0	1	0	22	1	3	4	0
530190	Samoa	32	32	28	3	0	3	0	28	0	0	0	28	0	0	1	0
TOTAL ALL SITES (82 sites)		3246	3097	2572	881	105	238	69	80	44	63	45	2161	117	211	409	20

RECORD TYPE	SR	PR	BS	NN	NS	BU	SP	LD	TL6	TL13	W	WA	T	DA	QA
PERCENT**	95.4	79.2	27.1	3.2	7.3	2.1	2.7	1.4	2.0	1.5	66.5	3.6	6.5	12.6	0.5

** computed as a percent of SR (site records)

NUMBER OF RECORDS BY SITE AND TYPE

Counts include dates beginning 4 JAN 1981 through 28 DEC 1981

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL18	W	WA	T	DA	QA
020300	Denali (McKinley) National Park	52	51	49	7	1	2	0	0	0	0	0	32	8	7	3	0
030180	Tombstone	35	28	28	8	7	5	0	0	0	0	0	16	0	1	11	0
030360	Oliver Knoll	18	18	18	1	0	2	0	0	0	0	0	5	1	2	9	1
030370	Grand Canyon National Park	20	20	19	6	0	2	3	0	0	0	0	9	1	3	6	1
030620	Organ Pipe Cactus National Monument	52	52	52	2	0	2	0	0	0	0	0	16	1	4	30	1
042700	Fayetteville	52	52	52	4	0	2	0	0	0	0	0	43	0	3	5	1
0534[illegible]0	Bishop	52	51	49	12	1	3	0	0	0	0	0	10	4	5	30	0
054540	Hopland	52	52	52	0	0	3	0	0	0	0	0	28	0	4	19	1
057550	Sequoia National Park	52	48	47	11	4	7	0	0	0	0	0	22	1	7	16	1
058500	Channel Islands National Park	52	43	34	23	6	16	0	29	3	4	3	11	1	7	21	0
058840	Davis Site	52	30	30	24	22	5	0	0	0	0	0	19	1	5	5	0
058950	Yosemite National Park	3	3	3	0	0	1	2	0	0	0	0	3	0	0	0	0
060060	Alamosa	52	52	52	7	0	1	0	0	0	0	0	27	4	6	14	1
061530	Mesa Verde National Park	35	33	32	3	0	1	0	0	2	2	2	25	0	5	3	0
061560	Sand Spring	52	52	51	8	0	5	0	0	0	0	0	38	2	2	9	1
061910	Rocky Mountain National Park	52	51	51	9	0	5	0	0	1	1	1	39	2	5	4	2
062120	Manitou	52	51	50	3	0	2	0	0	1	1	1	34	5	4	7	1
062220	Pawnee	52	52	52	6	0	5	0	0	0	0	0	28	4	4	13	3
100020	Austin-Cary Forest	28	28	28	1	0	2	0	0	0	0	0	16	0	1	11	0
100360	Bradford Forest	52	51	49	3	0	6	0	0	1	1	1	28	3	2	16	2
101190	Everglades National Park	53	53	53	4	0	19	0	1	0	0	0	38	3	9	3	0
114140	Georgia Station	52	52	52	1	0	9	4	0	0	0	0	38	0	3	9	2
120080	Mauna Loa	52	52	52	3	0	7	0	0	0	0	0	17	2	6	27	0
130340	Craters of the Moon	52	50	50	8	1	11	0	2	1	2	1	32	2	4	13	0
141160	Bondville	52	52	51	1	0	4	0	0	0	0	0	41	3	4	1	2
141800	NIARC	31	31	31	2	0	3	0	1	0	0	0	25	1	3	2	0
141980	Argonne	52	51	52	4	0	1	0	2	1	1	1	42	2	5	2	1
143580	SIU	52	52	50	4	0	5	0	11	0	0	0	43	2	3	2	1
144740	Salem	53	52	51	5	1	30	0	2	0	0	0	41	2	4	4	0
146340	Dixon Springs Agriculture Center	52	52	52	0	0	6	0	0	0	0	0	42	1	4	5	0
153420	Indiana Dunes National Lakeshore	11	10	10	2	1	0	0	10	0	0	0	6	1	2	1	0
153421	Indiana Dunes National Lakeshore	41	40	40	3	1	0	0	1	0	0	0	35	1	3	1	0
200010	Acadia National Park	44	44	43	5	0	4	0	0	0	0	0	40	0	1	2	0
200011	Acadia National Park	8	8	8	1	0	2	0	0	0	0	0	8	0	0	0	0
200045	Caribou	52	52	49	3	0	2	0	7	0	0	0	46	1	1	1	0
200277	Bridgton	52	52	52	20	0	3	0	1	0	0	0	46	1	3	2	0
200935	Greenville Station	55	55	55	3	0	3	0	5	0	0	0	52	1	1	0	1
220155	NACL	2	2	2	0	0	0	0	2	0	0	0	2	0	0	0	0
230920	Douglas Lake	52	51	51	7	1	4	9	2	0	0	0	41	1	4	4	1
232240	Houghton	52	32	31	21	20	2	2	0	0	0	0	27	3	0	1	0
232570	Isle Royale National Park	52	17	17	36	34	0	0	0	1	1	1	17	0	1	0	0
232660	Kellogg Biological Station	52	52	52	6	0	1	0	0	0	0	0	37	1	10	3	1
235340	Wellston	52	52	49	3	0	13	1	0	0	0	0	43	0	2	2	2
241660	Marcell Experimental Forest	52	52	52	2	0	1	0	2	0	0	0	41	2	6	1	2
241840	Fernberg	52	52	51	8	0	12	0	12	0	1	0	36	5	6	5	0
242720	Lamberton	52	52	52	3	0	1	0	0	0	0	0	33	2	2	15	0

NUMBER OF RECORDS BY SITE AND TYPE

(1981 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
251460	Meridian	52	52	52	3	0	1	0	2	0	1	0	40	2	6	4	0
260380	Ashland Wildlife Area	10	10	10	1	0	3	0	0	0	0	0	8	0	0	2	0
260560	University Forest	9	9	9	4	0	0	0	0	0	0	0	7	0	2	0	0
270570	Glacier Fire Weather	52	46	42	14	1	17	4	0	5	5	5	42	1	3	0	1
281520	Mead	52	52	52	3	0	2	0	0	0	0	0	31	4	6	11	0
300240	Hubbard Brook	52	52	52	0	0	0	0	0	0	0	0	47	3	1	1	0
312980	Princeton	27	27	27	5	0	0	0	27	0	0	0	22	0	3	2	0
312981	Washington Crossing	21	21	20	1	0	2	0	0	0	0	0	18	0	1	1	0
330860	Aurora Research Farm	52	52	52	0	0	7	0	2	0	0	0	46	2	3	1	0
331000	Chautauqua	52	51	51	4	1	2	0	0	0	0	0	47	1	0	2	1
331220	Knobit	52	51	52	0	0	2	0	2	1	2	1	49	1	1	0	1
332020	Huntington Wildlife	52	52	52	0	0	6	0	0	0	0	0	52	0	0	0	0
335140	Stilwell Lake	52	52	52	0	0	4	0	0	0	0	0	45	2	0	4	1
335240	Bennett Bridge	52	48	47	8	0	4	4	1	4	4	4	50	0	0	0	0
336500	Jasper	52	50	50	11	0	12	4	1	2	2	2	41	5	3	2	1
340320	Lewiston	52	52	52	1	0	4	0	0	0	0	0	43	2	5	2	0
341180	Research Triangle Institute	52	52	52	1	0	5	0	0	0	0	0	46	1	2	3	0
342500	Coweeta	52	52	52	0	0	2	0	2	0	0	0	43	4	3	2	0
343310	Research Triangle Park	52	52	52	1	0	0	0	0	0	0	0	43	4	3	2	0
343400	Piedmont Research Station	52	52	52	2	0	3	0	0	0	0	0	40	2	8	2	0
343560	Clinton Crops Research Station	52	52	52	3	0	2	0	0	0	0	0	41	4	6	1	0
344160	Finley (a)	52	52	52	4	0	4	0	4	0	0	0	38	2	6	5	1
350700	Theodore Roosevelt National Park	34	34	32	7	0	3	0	0	0	0	0	24	4	2	4	0
361760	Delaware	52	52	51	12	0	4	0	0	0	0	0	39	3	4	5	1
364900	Caldwell	52	52	52	13	0	0	0	0	0	0	0	45	2	2	3	0
367160	Wooster	52	52	52	8	0	3	0	0	0	0	0	41	4	3	4	0
380200	Alsea Guard Ranger Station	52	52	52	0	0	9	0	0	0	0	0	39	4	3	6	0
380201	Schmidt Farm	52	51	50	4	1	1	0	1	0	0	0	36	3	3	8	1
380840	Lost Creek Dam	50	48	48	2	1	1	0	5	1	2	2	32	2	3	12	0
381020	H. J. Andrews Experimental Forest	52	52	52	3	0	2	0	0	0	0	0	38	1	4	9	0
381120	Vines Hill	52	49	48	21	2	23	0	1	1	1	1	29	2	5	14	0
381780	Pendleton	52	52	52	4	0	3	0	38	0	0	0	30	2	9	11	0
392940	Kane Experimental Forest	52	52	51	1	0	25	1	0	0	0	0	49	2	0	0	0
394200	Leading Ridge	52	52	52	1	0	3	0	0	0	0	0	46	0	4	1	1
421880	Clemson	52	52	52	2	0	1	0	52	0	0	0	35	2	9	6	0
430060	Huron	52	48	37	20	0	0	0	0	4	4	4	29	1	7	6	0
440040	Walker Branch Watershed	52	52	52	1	0	3	0	0	0	0	0	47	0	4	1	0
441190	Elkmont	52	52	52	0	0	11	0	0	0	0	0	46	4	2	0	0
450425	K-Bar	52	52	52	7	0	1	0	0	0	0	0	27	1	8	16	0
453800	Forest Seed Center	19	18	16	11	0	0	0	0	1	1	1	17	1	0	1	0
455350	Victoria	53	50	50	8	0	1	0	2	3	3	3	37	1	5	10	0
460280	Cedar Mountain	24	23	20	10	0	8	0	10	1	5	2	17	0	3	4	0
470100	Bennington	37	37	37	1	0	4	0	4	0	0	0	34	2	1	0	0
481800	Horton's Station	52	52	50	0	0	0	21	25	0	0	0	37	4	3	8	0
482890	Big Meadows	33	29	27	7	1	10	5	0	3	3	3	29	2	0	1	0
491410	Olympic National Park	52	52	52	1	0	4	0	2	0	1	0	47	0	2	3	0

NUMBER OF RECORDS BY SITE AND TYPE

(1981 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
501860	Parsons	52	52	52	1	0	0	0	0	0	0	0	49	1	1	1	0
513640	Trout Lake	52	52	52	7	0	6	0	0	0	0	0	42	2	6	1	1
513700	Spooner	52	52	49	8	0	17	0	1	0	0	0	28	4	3	15	0
520820	Newcastle	20	19	19	7	0	0	0	0	1	1	1	10	3	3	4	0
520860	Yellowstone National Park	52	52	51	7	0	7	0	3	0	0	0	33	4	9	6	0
530190	Samoa	52	52	52	2	0	9	0	51	0	0	0	51	1	0	0	0
775048	Kejimkujik National Park	34	29	25	12	1	28	0	2	4	4	4	20	1	1	2	0
775070	Lethbridge	35	33	29	11	0	1	0	4	2	2	2	23	3	6	3	0
776000	Mount Forest	34	32	30	6	0	6	0	0	2	2	2	33	0	1	0	0
TOTAL ALL SITES (101 sites)		4569	4415	4338	582	108	491	66	334	46	57	48	3306	181	342	550	39

RECORD TYPE	SR	PR	BS	NN	NS	BU	SP	LD	TL6	TL13	W	WA	T	DA	QA
PERCENT**	96.6	94.9	12.7	2.4	10.8	1.4	7.3	1.0	1.3	1.1	72.4	4.0	7.5	12.0	0.8

** computed as a percent of SR (site records)

NUMBER OF RECORDS BY SITE AND TYPE

Counts include dates beginning 4 JAN 1982 through 28 DEC 1982

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
020390	Denali (McKinley) National Park	52	46	45	19	2	4	3	4	4	4	4	40	3	6	1	0
030360	Oliver Knoll	52	52	52	2	0	2	0	3	0	0	0	30	2	4	16	0
030870	Grand Canyon National Park	52	52	52	16	0	7	0	0	0	0	0	37	1	5	9	0
030620	Organ Pipe Cactus National Monument	52	52	52	8	0	10	0	0	0	0	0	18	4	8	20	1
040280	Warren 2WSW	31	31	31	1	0	0	0	0	0	0	0	25	1	3	1	0
041620	Buffalo River	24	24	24	1	0	0	0	0	0	0	0	17	1	3	3	0
042700	Fayetteville	52	52	52	4	0	3	0	0	0	1	0	38	1	5	8	0
053460	Bishop	25	24	24	4	1	1	0	0	0	0	0	9	1	2	12	0
054200	Tanbark Flat	50	50	50	3	0	4	0	0	0	0	0	27	4	3	16	0
054540	Hopland	52	52	52	2	0	9	0	0	0	0	0	25	1	5	19	1
057550	Sequoia National Park	52	52	52	1	0	5	0	2	0	1	0	32	3	3	13	1
058500	Channel Islands National Park	6	5	5	4	1	0	0	2	0	2	0	3	0	1	0	1
058840	Davis Site	52	51	51	2	0	0	0	2	1	2	1	21	0	4	27	0
058850	Yosemite National Park	51	49	49	8	0	9	2	0	2	2	2	31	2	5	13	0
060060	Alamosa	52	42	42	16	10	2	0	0	0	0	0	21	2	6	12	0
061530	Mesa Verde National Park	52	52	52	3	0	5	0	2	0	1	0	36	4	4	7	1
061580	Sand Spring	52	52	52	4	0	3	0	0	0	0	0	39	7	1	4	1
061910	Rocky Mountain National Park	52	52	52	1	0	5	0	0	0	0	0	41	3	6	1	1
062120	Manitou	52	51	51	4	0	6	0	0	1	1	1	34	4	5	9	0
062220	Pawnee	52	52	52	3	0	0	0	0	0	0	0	29	2	5	14	2
100360	Bradford Forest	52	51	51	1	0	2	0	0	1	1	1	44	1	1	6	0
101160	Everglades National Park	53	53	53	5	0	4	0	4	0	0	0	44	2	6	1	0
114140	Georgia Station	52	52	52	2	0	3	0	0	0	0	0	43	0	5	4	0
120080	Mauna Loa	52	52	52	3	0	2	0	0	0	0	0	36	1	2	13	0
130340	Craters of the Moon	52	50	50	12	0	11	7	0	2	2	2	40	3	2	6	1
130480	Headquarters	28	23	21	12	0	8	1	8	0	0	0	19	1	1	2	0
141160	Bondville	52	52	52	4	0	3	0	2	0	0	0	42	4	4	2	0
141800	NIARC	52	52	52	3	0	2	0	0	0	0	0	38	4	8	2	0
141960	Argonne	52	50	50	5	0	1	0	3	2	2	2	40	4	5	2	1
143580	SIU	52	52	52	10	0	0	0	0	0	0	0	45	1	4	1	1
144740	Salem	52	52	51	3	0	1	0	0	0	0	0	41	3	4	3	0
146340	Dixon Springs Agriculture Center	52	52	52	0	0	0	0	0	0	0	0	44	2	4	2	0
153421	Indiana Dunes National Lakeshore	52	51	50	3	1	2	0	0	0	0	0	43	2	4	2	0
154100	Purdue University Ag. Farm	24	24	24	2	0	0	0	0	0	0	0	21	2	1	0	0
173120	Konza Prairie	19	19	19	3	0	0	0	0	0	0	0	14	1	4	0	0
190620	Hill Farm Research Station	6	5	6	0	0	4	0	0	1	1	1	6	0	0	0	0
191260	Iberia Research Station	6	5	5	0	0	0	0	0	1	1	1	6	0	0	0	0
200011	Acadia National Park	52	52	52	2	0	25	0	10	0	1	0	50	1	0	1	0
200045	Caribou	52	52	52	1	0	4	0	2	0	1	0	44	2	3	3	0
200277	Bridgton	52	52	52	10	0	16	0	0	0	0	0	46	1	2	3	0
200985	Greenville Station	52	52	52	1	0	2	0	0	0	0	0	48	1	2	0	1
220155	NACL	52	52	52	3	0	1	0	38	0	1	0	45	1	3	2	1
220815	Cadwell	43	43	42	4	0	1	0	6	0	1	0	36	1	5	1	0
221325	East	47	47	47	2	0	2	0	2	0	0	0	40	0	3	4	0
230020	Douglas Lake	52	51	50	3	0	5	0	4	1	1	1	48	1	2	1	0
232240	Houghton	52	33	33	22	10	6	0	0	0	0	0	28	2	0	3	0

NUMBER OF RECORDS BY SITE AND TYPE

(1982 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
232570	Isle Royale National Park	52	20	20	34	32	1	0	0	0	0	0	18	1	0	1	0
232660	Kellogg Biological Station	52	51	51	9	0	6	1	0	1	1	1	41	2	6	3	0
235340	Wellston	52	52	52	2	0	13	7	0	0	0	0	46	2	2	1	1
241660	Marcell Experimental Forest	52	52	52	6	0	2	0	1	0	1	0	46	2	4	0	0
241840	Fernberg	52	52	52	4	0	3	0	0	0	0	0	42	3	4	3	0
242720	Lamberton	52	52	52	0	0	2	0	1	0	0	0	33	2	5	12	0
251460	Meridian	52	52	52	2	0	3	3	0	0	0	0	43	0	7	2	0
260380	Ashland Wildlife Area	52	52	52	1	0	4	0	0	0	0	0	42	2	4	4	0
260560	University Forest	52	52	52	6	0	3	0	0	0	0	0	44	2	6	0	0
270570	Glacier Fire Weather	52	51	51	8	0	0	0	2	1	1	1	50	0	1	1	0
271340	Give Out Morgan	15	15	15	2	0	0	0	4	0	0	0	7	0	4	4	0
281520	Mead	52	52	52	6	0	4	0	1	0	0	0	34	2	6	9	1
300240	Hubbard Brook	52	52	52	0	0	6	1	0	0	0	0	47	2	1	0	2
312981	Washington Crossing	52	52	52	2	0	14	0	3	0	1	0	42	1	6	3	0
320720	Bandelier	27	25	23	8	0	9	0	2	2	2	2	21	1	1	3	1
320980	CUBA	47	46	44	14	1	10	4	3	0	0	0	28	2	6	10	0
330860	Aurora Research Farm	52	52	52	1	0	1	0	0	0	0	0	46	1	2	3	0
331060	Chautauqua	52	52	52	3	0	2	1	0	0	0	0	44	4	2	2	0
331220	Knobit	51	51	50	3	0	2	0	2	0	0	0	45	2	2	2	0
332020	Huntington Wildlife	52	52	52	1	0	2	0	2	0	0	0	48	1	1	2	0
335140	Stilwell Lake	52	52	52	2	0	2	0	2	0	0	0	44	3	4	1	0
335240	Bennett Bridge	51	46	46	10	2	7	5	0	3	3	3	43	3	2	1	0
336500	Jasper	52	52	50	14	0	2	10	5	0	0	0	45	1	2	4	0
340320	Lewiston	52	52	52	0	0	3	0	0	0	0	0	43	1	3	5	0
341180	Research Triangle Institute	52	52	52	3	0	4	0	0	0	0	0	42	1	5	4	0
342500	Coweeta	52	52	52	1	0	3	0	2	0	0	0	49	1	2	0	0
343310	Research Triangle Park	52	52	52	3	0	2	0	0	0	0	0	42	0	3	7	0
343460	Piedmont Research Station	52	52	52	0	0	2	0	0	0	0	0	45	2	4	1	0
343560	Clinton Crops Research Station	52	52	52	4	0	11	0	0	0	0	0	44	0	4	4	0
344160	Finley (a)	52	51	52	2	0	9	0	0	1	1	1	46	0	4	2	0
350700	Theodore Roosevelt National Park	52	49	49	9	0	1	0	1	3	3	3	38	5	5	3	1
361760	Delaware	52	52	52	11	0	1	0	0	0	0	0	44	4	2	2	0
364900	Caldwell	52	52	52	8	0	0	0	4	0	0	0	45	1	1	5	0
367160	Wooster	52	52	52	7	0	1	4	1	0	0	0	47	2	2	1	0
380200	Alsea Guard Ranger Station	52	50	49	3	1	13	0	0	1	1	1	40	2	3	6	0
380201	Schmidt Farm	52	45	44	22	6	2	0	0	1	1	1	37	2	2	5	0
380280	Bull Run	24	24	24	9	0	3	3	24	0	0	0	22	1	0	1	0
380840	Lost Creek Dam	52	47	47	8	0	2	0	10	5	8	5	38	1	6	7	0
381020	H. J. Andrews Experimental Forest	52	51	51	6	0	7	0	4	1	2	1	44	2	4	2	0
381120	Vines Hill	52	51	51	24	1	50	0	2	0	0	0	21	2	5	23	0
381780	Pendleton	24	24	24	4	0	2	0	2	0	2	0	17	1	4	2	0
392940	Kane Experimental Forest	52	51	51	3	0	5	5	0	1	1	1	46	1	3	2	0
394200	Leading Ridge	52	52	52	0	0	0	0	0	0	0	0	47	2	1	2	0
421880	Clemson	52	52	52	2	0	0	0	52	0	0	0	48	0	2	2	0
430060	Huron	52	44	43	16	0	10	4	0	8	8	8	33	6	9	4	0
440040	Walker Branch Watershed	52	52	52	2	0	3	0	0	0	0	0	49	1	1	1	0

NUMBER OF RECORDS BY SITE AND TYPE

(1982 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL6	TL13	W	WA	T	DA	QA
441190	Elkmont	52	50	49	14	1	6	0	0	1	1	1	50	0	1	0	0
450425	K-Bar	52	52	52	4	0	5	0	0	0	0	0	23	1	0	19	0
452180	Longview	25	26	26	3	0	0	0	0	0	0	0	20	0	3	3	0
453800	Forest Seed Center	52	52	52	6	0	8	0	0	0	0	0	41	3	1	7	0
455350	Victoria	52	52	52	11	0	4	0	2	0	0	0	35	1	4	12	0
460280	Cedar Mountain	51	48	45	25	0	5	0	11	3	3	3	30	0	0	6	0
470100	Bennington	52	49	50	6	0	1	0	0	3	3	3	48	1	2	1	0
481300	Horton's Station	52	52	51	9	0	25	0	52	0	1	0	45	2	1	4	0
482890	Big Meadows	52	49	48	5	0	10	0	0	3	3	3	46	3	2	1	0
491410	Olympic National Park	53	52	52	3	0	2	0	4	1	2	1	46	4	1	2	0
501860	Parsons	52	52	52	0	0	0	0	0	0	0	0	48	1	2	1	0
512800	Lake Dubay	25	26	26	1	0	1	0	0	0	0	0	23	0	3	0	0
513640	Trout Lake	52	52	52	5	0	7	0	3	0	0	0	45	4	3	0	0
513700	Spooner	52	52	52	4	0	7	0	4	0	0	0	44	2	0	6	0
520680	Pinedale	48	48	48	3	0	2	5	2	0	0	0	34	5	4	5	0
520820	Newcastle	52	52	52	1	0	2	0	1	0	0	0	40	4	4	2	2
520860	Yellowstone National Park	52	49	48	11	0	7	8	8	3	5	3	47	3	1	0	1
530190	Samoa	52	52	49	4	0	12	3	4	0	0	0	45	4	1	1	0
775048	Kejimkujik National Park	52	49	49	4	2	14	0	1	1	1	1	43	3	3	1	0
775070	Lethbridge	52	51	51	5	0	6	0	2	1	1	1	32	4	3	13	0
776000	Mount Forest	52	49	49	3	0	35	0	0	3	3	3	44	3	2	3	0
TOTAL ALL SITES (113 sites)		5375	5232	5208	632	80	572	104	318	63	85	63	4161	218	371	518	23

RECORD TYPE	SR	PR	BS	NN	NS	BU	SP	LD	TL6	TL13	W	WA	T	DA	QA
PERCENT**	97.3	96.9	11.7	1.5	10.6	1.9	5.9	1.2	1.6	1.2	77.4	4.1	6.9	9.6	0.4

** computed as a percent of SR (site records)

NUMBER OF RECORDS BY SITE AND TYPE

Counts include dates beginning 4 JAN 1983 through 29 DEC 1983

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL18	W	WA	T	DA	QA
011000	Blackbelt Substation	18	18	18	0	0	0	0	18	0	0	0	16	0	0	2	0
020300	Denali (McKinley) National Park	52	49	46	14	0	1	0	0	3	3	3	32	7	8	4	1
030360	Oliver Knoll	52	52	52	1	0	5	6	2	0	1	0	28	1	6	16	1
030370	Grand Canyon National Park	52	52	52	4	0	1	0	0	0	0	0	35	2	5	10	0
030620	Organ Pipe Cactus National Monument	52	52	52	4	0	2	0	0	0	0	0	25	2	4	20	1
040280	Warren 2WSW	52	51	51	1	0	2	0	0	1	1	1	48	0	3	2	1
040380	Caddo Valley	1	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0
041620	Buffalo River	52	52	52	7	0	9	2	0	0	0	0	37	4	9	2	0
042700	Fayetteville	52	52	51	3	0	1	0	0	0	0	0	40	0	3	8	0
054200	Tanbark Flat	52	52	52	2	0	2	0	0	0	0	0	27	1	7	16	1
054540	Hopland	52	52	52	0	0	3	0	0	0	0	0	33	1	1	16	1
056820	Palomar Mountain	42	42	42	4	0	4	0	0	0	0	0	19	4	3	16	0
057550	Sequoia National Park	52	52	50	18	0	12	0	2	0	0	0	31	1	4	16	0
058501	Chuchupate Ranger Station	22	22	22	4	0	5	0	19	0	0	0	9	1	3	9	0
058840	Davis Site	52	52	52	6	0	2	0	2	0	0	0	25	1	5	20	0
058850	Yosemite National Park	53	53	53	5	0	1	0	3	0	1	0	35	2	3	13	0
060060	Alamosa	52	52	52	8	0	12	3	0	0	0	0	25	7	8	11	0
060180	Las Animas Fish Hatchery	13	13	13	3	0	4	0	13	0	0	0	4	2	1	6	0
061530	Mesa Verde National Park	52	52	52	3	0	5	0	0	0	0	0	35	4	6	7	0
061560	Sand Spring	52	52	52	4	0	5	0	4	0	0	0	44	3	4	0	1
061910	Rocky Mountain National Park	53	52	53	5	0	1	0	2	1	1	1	44	5	1	3	0
061911	Loch Vale	20	20	20	6	0	3	0	0	0	0	0	18	2	0	0	0
062120	Manitou	52	52	52	4	0	2	0	0	0	0	0	36	3	7	6	0
062220	Pawnee	52	52	52	5	0	1	0	0	0	0	0	30	4	6	10	2
100360	Bradford Forest	52	51	51	1	1	5	0	6	0	1	0	44	1	2	4	0
100380	CIFANT	22	22	22	3	0	6	0	0	0	0	0	21	0	1	0	0
101190	Everglades National Park	53	51	50	7	0	4	4	3	2	2	2	45	2	4	2	0
104100	Verna Well Field	19	19	19	1	0	2	5	19	0	0	0	12	0	4	3	0
112040	Bellville	36	36	36	6	0	0	0	0	0	0	0	30	0	2	4	0
114140	Georgia Station	52	52	52	3	0	5	0	0	0	0	0	43	1	7	1	0
115000	Tifton, ARS	13	13	13	0	0	1	0	13	0	0	0	12	0	1	0	0
120080	Mauna Loa	52	52	52	2	0	0	0	0	0	0	0	12	3	3	34	0
130340	Craters of the Moon	52	50	48	10	0	9	9	0	2	2	2	39	2	3	6	2
130480	Headquarters	51	50	48	11	0	7	1	12	1	3	1	43	1	2	5	0
131180	Reynolds Creek	5	5	5	0	0	3	0	0	0	0	0	5	0	0	0	0
141160	Bondville	52	52	52	8	0	3	0	0	0	0	0	36	1	11	4	0
141161	Bondville Intercomparison	15	15	15	1	0	1	0	0	0	0	0	13	0	1	1	0
141800	NIARC	52	52	52	2	0	1	4	0	0	0	0	44	1	7	0	0
141980	Argonne	52	51	51	6	0	2	0	0	1	1	1	44	1	5	1	1
143580	SIU	52	52	52	4	0	1	0	0	0	0	0	40	3	8	1	0
144740	Salem	52	51	50	8	0	4	0	0	1	1	1	36	1	5	10	0
146340	Dixon Springs Agriculture Center	52	52	52	1	0	1	0	0	0	0	0	39	1	7	5	0
152020	Huntington Reservoir	19	18	18	3	0	4	0	19	1	1	1	15	0	4	0	0
153421	Indiana Dunes National Lakeshore	52	52	51	5	0	0	0	0	0	0	0	43	3	4	2	0
154100	Purdue University Ag. Farm	52	52	52	3	0	5	0	0	0	0	0	41	4	2	5	0
173120	Konza Prairie	52	51	51	7	0	0	0	0	1	1	1	30	2	6	4	1

NUMBER OF RECORDS BY SITE AND TYPE

(1983 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL18	W	WA	T	DA	QA
180300	Perryville	5	4	4	2	0	0	0	0	1	1	1	5	0	0	0	0
182260	Lilley Cornett Woods	17	17	17	0	0	2	0	0	0	0	0	15	1	1	0	0
183560	Clark State Fish Hatchery	18	18	18	1	0	4	0	18	0	0	0	16	0	0	2	0
190620	Hill Farm Research Station	52	50	50	5	0	7	7	1	2	2	2	38	0	8	6	0
191260	Iberia Research Station	52	49	49	4	0	3	0	4	3	4	3	45	1	4	2	0
193060	Southeast Research Station	50	46	46	6	1	3	7	4	3	4	3	42	0	3	4	0
200011	Acadia National Park	53	53	53	1	0	4	10	1	0	0	0	47	2	3	0	1
200045	Caribou	52	50	50	4	0	5	4	4	2	2	2	45	1	4	2	0
200277	Bridgton	52	45	45	7	7	1	0	0	0	0	0	43	1	1	0	0
200935	Greenville Station	52	52	52	1	0	5	0	0	0	0	0	48	2	2	0	0
211320	Wye	43	43	43	0	0	2	0	0	0	0	0	40	0	1	2	0
220155	NACL	52	51	51	2	0	11	9	0	1	1	1	46	0	2	4	0
220815	Cadwell	52	51	51	2	0	7	12	0	1	1	1	37	2	3	10	0
221325	East	52	52	52	2	0	1	0	0	0	0	0	47	0	2	2	1
230920	Douglas Lake	52	51	51	2	0	6	0	0	1	1	1	46	1	2	3	0
232240	Houghton	6	6	6	0	0	0	0	0	0	0	0	5	1	0	0	0
232241	Chassell	46	45	44	4	1	3	0	2	0	0	0	40	2	1	2	0
232570	Isle Royale National Park	52	21	21	35	30	0	0	0	1	1	1	19	0	2	1	0
232660	Kellogg Biological Station	52	52	52	8	0	6	3	5	0	0	0	41	4	4	3	0
235340	Wellston	52	52	52	0	0	3	0	0	0	0	0	49	0	1	2	0
241660	Marcell Experimental Forest	52	52	52	1	0	4	5	0	0	0	0	43	2	3	4	0
241840	Fernberg	52	51	51	4	0	1	0	0	1	1	1	42	2	5	3	0
242360	Camp Ripley	11	11	11	3	0	5	3	11	0	0	0	6	1	4	0	0
242720	Lamberton	53	53	53	4	0	5	3	4	0	0	0	35	4	6	8	0
251460	Meridian	52	52	52	1	0	5	1	0	0	0	0	43	0	4	5	0
260380	Ashland Wildlife Area	52	52	52	2	0	2	0	2	0	0	0	44	2	4	2	0
260560	University Forest	52	52	52	3	0	2	0	0	0	0	0	42	1	6	3	0
270560	St. Mary Ranger Station	49	45	42	9	0	2	0	3	4	4	4	40	3	6	0	0
270570	Glacier Fire Weather	52	52	50	3	0	4	0	3	0	0	0	41	5	2	2	1
271340	Give Out Morgan	52	52	52	7	0	9	0	6	0	2	0	24	4	8	15	1
281520	Mead	53	53	53	5	0	4	0	1	0	0	0	37	0	9	6	1
300240	Hubbard Brook	52	52	52	0	0	2	3	0	0	0	0	50	0	1	1	0
312981	Washington Crossing	52	52	52	0	0	8	0	2	0	0	0	41	0	4	7	0
320720	Bandelier	53	53	53	14	0	4	0	4	0	0	0	39	1	6	6	1
320980	CUBA	52	51	51	7	0	6	0	0	1	1	1	37	1	6	7	1
330860	Aurora Research Farm	53	53	53	1	0	0	0	0	0	0	0	48	0	2	4	0
331000	Chautauqua	52	52	52	1	0	2	0	0	0	0	0	44	1	6	1	0
331220	Knobit	52	48	48	3	0	2	1	1	4	4	4	48	0	0	4	0
332020	Huntington Wildlife	52	52	52	2	0	1	5	2	0	0	0	49	1	2	0	0
335140	Stilwell Lake	52	52	52	1	0	5	0	0	0	0	0	45	2	3	2	0
335141	West Point	16	16	16	0	0	0	0	0	0	0	0	15	1	0	0	0
335240	Bennett Bridge	52	51	50	3	0	1	0	4	1	1	1	48	0	0	3	0
336500	Jasper	52	52	51	8	0	4	0	0	0	0	0	45	1	4	2	0
336840	Biscuit Brook	12	12	12	0	0	2	1	12	0	1	0	11	0	0	1	0
340320	Lewiston	52	52	52	0	0	3	0	1	0	0	0	43	0	2	7	0
342500	Coweeta	52	50	50	3	0	9	1	0	2	2	2	46	0	4	2	0

NUMBER OF RECORDS BY SITE AND TYPE

(1983 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
343310	Research Triangle Park	8	8	8	1	0	0	0	0	0	0	0	6	0	1	1	0
343460	Piedmont Research Station	52	52	52	1	0	1	0	0	0	0	0	44	0	4	4	0
343560	Clinton Crops Research Station	52	51	51	1	1	0	0	0	0	0	0	39	1	5	6	0
343600	Jordan Creek	11	11	11	1	0	1	0	0	0	0	0	10	0	1	0	0
344100	Finley (a)	52	52	52	1	0	5	0	0	0	0	0	47	0	2	3	0
350700	Theodore Roosevelt National Park	52	49	49	14	1	3	0	0	2	2	2	31	7	9	2	2
350880	Icelandic State Park	10	10	10	4	0	2	0	0	0	0	0	1	2	4	3	0
351180	Woodworth	5	5	5	0	0	4	0	0	0	0	0	0	1	1	3	0
361760	Delaware	52	52	52	5	0	1	0	0	0	0	0	45	4	1	2	0
364900	Caldwell	52	52	52	3	0	2	0	0	0	0	0	49	0	2	1	0
367160	Wooster	52	52	52	3	0	2	0	0	0	0	0	45	1	5	1	0
370060	Salt Plains National Wildlife Ref.	3	3	2	2	0	1	0	0	0	0	0	0	1	1	1	0
371740	Great Plains Apiaries	40	39	39	6	0	4	0	5	1	2	1	28	2	3	7	0
372580	Clayton Lake	48	48	48	5	0	5	0	0	0	0	0	38	2	4	4	0
380200	Alsea Guard Ranger Station	52	52	52	2	0	8	4	0	0	0	0	43	1	3	5	0
380201	Schmidt Farm	16	16	16	16	0	1	0	0	0	0	0	15	0	1	0	0
380202	Hyslop	36	36	36	5	0	2	0	0	0	0	0	28	1	3	4	0
380260	Bull Run	52	52	52	1	0	5	4	52	0	0	0	48	0	1	3	0
380840	Lost Creek Dam	48	47	47	3	0	3	0	3	1	1	1	36	1	5	5	1
380980	Silver Lake Ranger Station	19	19	19	0	0	1	5	19	0	0	0	15	0	0	4	0
381020	H. J. Andrews Experimental Forest	52	52	52	3	0	12	0	0	0	0	0	45	2	2	3	0
381120	Vines Hill	53	50	48	18	0	4	0	6	3	4	3	37	3	6	7	0
391520	Penn State	30	30	30	1	0	4	0	0	0	0	0	28	0	1	1	0
391521	Penn State Intercomparison	13	13	13	0	0	0	0	13	0	0	0	12	0	0	1	0
392940	Kane Experimental Forest	52	52	52	1	0	3	5	0	0	0	0	48	1	1	2	0
394200	Leading Ridge	52	52	52	1	0	2	0	0	0	0	0	47	1	1	3	0
397220	Milford	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
421880	Clemson	52	52	52	6	0	1	0	52	0	1	0	42	2	5	3	0
430060	Huron	37	32	28	13	0	0	0	0	5	5	5	27	4	4	2	0
430061	Huron Well Field	5	5	5	2	0	1	2	0	0	0	0	2	0	1	2	0
430880	Cottonwood	12	1.	11	1	0	1	0	0	1	1	1	8	1	1	2	0
440040	Walker Branch Watershed	52	52	52	1	0	1	0	0	0	0	0	44	0	3	4	1
441190	Elkmont	52	51	50	13	0	10	0	5	1	2	1	48	1	3	0	0
450425	K-Bar	52	52	52	4	0	0	0	0	0	0	0	25	3	4	18	1
452180	Longview	52	52	52	8	0	2	0	2	0	0	0	37	2	7	5	1
453800	Forest Seed Center	53	53	53	3	0	5	0	4	0	0	0	41	4	1	7	0
455350	Victoria	53	53	53	7	0	3	0	2	0	0	0	40	1	6	6	0
455640	LBJ National Grasslands	15	14	14	1	0	0	0	15	1	1	1	10	0	3	2	0
460120	Logan	4	4	4	1	0	1	0	0	0	0	0	4	0	0	0	0
460280	Cedar Mountain	52	41	32	25	0	5	0	4	11	11	11	43	3	3	3	0
470100	Bennington	52	51	49	10	0	1	0	0	1	1	1	49	1	1	3	0
481300	Horton's Station	52	52	52	13	0	6	3	52	0	0	0	38	0	4	10	0
482800	Big Meadows	52	52	52	3	0	12	3	2	0	0	0	38	4	8	2	0
491410	Olympic National Park	57	57	57	2	0	3	0	12	0	0	0	53	1	2	1	0
500460	Babcock State Park	17	17	17	0	0	3	0	17	0	0	0	15	2	0	0	0
501860	Parsons	52	52	52	0	0	1	0	0	0	0	0	50	0	1	1	0

NUMBER OF RECORDS BY SITE AND TYPE

(1983 Continued)

		MISSING RECORDS					PROBLEM RECORDS						LABTYPES				
NUMBER	STATION	TR	SR	PR	BS	NN	NS	BU	SP	LD	TL8	TL13	W	WA	T	DA	QA
512800	Lake Dubay	52	52	51	6	0	3	0	1	0	0	0	38	6	4	4	0
513640	Trout Lake	52	51	51	8	0	9	0	0	1	1	1	43	2	2	5	0
513700	Spooner	52	52	52	2	0	5	0	0	0	0	0	40	2	2	7	1
520650	Pinedale	52	52	52	3	0	7	13	4	0	0	0	40	5	2	5	0
520820	Newcastle	53	53	52	16	0	1	0	0	0	0	0	37	4	4	7	1
520860	Yellowstone National Park	52	50	49	18	0	22	9	5	2	3	2	42	0	9	1	0
530190	Samoa	52	52	52	1	0	3	0	2	0	0	0	51	0	0	1	0
775048	Kejimkujik National Park	52	52	52	2	0	23	0	0	0	0	0	44	3	3	2	0
775070	Lethbridge	52	51	51	4	0	3	0	0	1	1	1	33	4	3	12	0
776000	Mount Forest	52	50	45	8	0	6	0	0	2	2	2	48	2	1	1	0
TOTAL ALL SITES (148 sites)		6320	6203	6156	660	42	523	157	510	75	90	75	4909	222	481	638	28

RECORD TYPE	SR	PR	BS	NN	NS	BU	SP	LD	TL6	TL13	W	WA	T	DA	QA
PERCENT**	98.2	97.4	10.4	0.7	8.2	2.5	8.1	1.2	1.5	1.2	77.7	3.5	7.6	10.1	0.4

** computed as a percent of SR (site records)

Minimum, Maximum and Average Dry Wet-Side Sample Summary by Site

Average values presented are simple arithmetic averages. Since Dry Wet-Side samples always have 50 ml of water added to them, multiplication of these numbers by 0.050 Liters per bucket will yield the minimum, average and/ or maximum micrograms of constituent in each sites Dry Wet-Side buckets.

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
011000		Min	0.070	0.011	0.012	0.046	0.020	0.100	0.080	0.180
011000	2	Avg	0.120	0.038	0.188	0.166	0.040	0.140	0.230	0.360
011000		Max	0.170	0.064	0.363	0.286	0.060	0.180	0.380	0.540
020390		Min	0.010	0.004	0.003	0.017	0.020	0.020	0.060	0.100
020390	3	Avg	0.050	0.049	0.072	0.237	0.057	0.040	0.120	0.260
020390		Max	0.110	0.130	0.161	0.549	0.110	0.060	0.180	0.560
030360		Min	0.010	0.003	0.003	0.009	0.020	0.020	0.020	0.100
030360	33	Avg	0.079	0.016	0.030	0.073	0.073	0.076	0.122	0.453
030360		Max	0.370	0.074	0.250	0.326	0.880	0.370	0.450	9.310
030370		Min	0.010	0.008	0.003	0.008	0.020	0.020	0.020	0.100
030370	20	Avg	0.156	0.029	0.046	0.282	0.043	0.169	0.156	0.268
030370		Max	0.440	0.060	0.377	1.620	0.130	1.990	0.920	1.330
030620		Min	0.010	0.003	0.003	0.009	0.020	0.020	0.020	0.100
030620	44	Avg	0.163	0.021	0.034	0.080	0.093	0.085	0.119	0.699
030620		Max	3.010	0.153	0.319	0.280	1.630	0.640	0.550	15.640
040260		Min	0.020	0.010	0.015	0.027	0.040	0.050	0.060	0.100
040260	3	Avg	0.050	0.017	0.020	0.048	0.067	0.073	0.113	0.183
040260		Max	0.100	0.024	0.027	0.066	0.100	0.090	0.180	0.350
041620		Min	0.020	0.017	0.004	0.016	0.020	0.020	0.090	0.100
041620	4	Avg	0.077	0.024	0.021	0.102	0.025	0.040	0.123	0.133
041620		Max	0.110	0.031	0.043	0.178	0.040	0.060	0.190	0.230
042700		Min	0.010	0.003	0.003	0.005	0.020	0.020	0.020	0.100
042700	17	Avg	0.137	0.018	0.031	0.176	0.056	0.195	0.104	0.264
042700		Max	1.050	0.052	0.120	1.160	0.210	1.230	0.300	1.580
053460		Min	0.010	0.002	0.003	0.012	0.020	0.040	0.020	0.060
053460	28	Avg	0.059	0.013	0.039	0.110	0.051	0.094	0.121	0.199
053460		Max	0.210	0.033	0.565	1.050	0.190	0.220	1.560	0.650
054200		Min	0.010	0.003	0.003	0.009	0.020	0.020	0.020	0.100
054200	30	Avg	0.068	0.024	0.035	0.161	0.054	0.314	0.113	0.261
054200		Max	0.380	0.177	0.119	1.000	0.390	4.850	0.490	1.140
054540		Min	0.010	0.003	0.002	0.005	0.020	0.020	0.020	0.100
054540	35	Avg	0.042	0.017	0.027	0.062	0.034	0.069	0.092	0.199
054540		Max	0.130	0.161	0.158	0.326	0.110	0.210	0.240	0.990

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
056820		Min	0.050	0.011	0.008	0.025	0.020	0.020	0.070	0.100
056820	13	Avg	0.831	0.060	0.036	0.156	0.052	0.048	2.098	0.159
056820		Max	5.290	0.157	0.137	0.472	0.220	0.130	9.470	0.320
057550		Min	0.010	0.003	0.006	0.012	0.020	0.020	0.020	0.100
057550	30	Avg	0.065	0.019	0.028	0.068	0.050	0.105	0.087	0.228
057550		Max	0.490	0.086	0.178	0.307	0.260	0.410	0.210	2.310
058500		Min	0.220	0.241	0.108	1.810	0.120	0.750	2.920	0.880
058500	6	Avg	0.828	1.880	0.601	14.768	0.247	3.858	23.273	4.370
058500		Max	1.700	5.760	1.640	45.600	0.350	11.460	65.810	9.900
058501		Min	0.060	0.016	0.046	0.044	0.020	0.020	0.130	0.410
058501	1	Avg	0.060	0.016	0.046	0.044	0.020	0.020	0.130	0.410
058501		Max	0.060	0.016	0.046	0.044	0.020	0.020	0.130	0.410
058840		Min	0.010	0.003	0.003	0.008	0.020	0.020	0.020	0.100
058840	46	Avg	0.059	0.026	0.057	0.067	0.054	0.085	0.105	0.179
058840		Max	0.370	0.247	0.450	0.362	0.340	0.650	0.560	0.890
058850		Min	0.010	0.003	0.004	0.005	0.020	0.020	0.020	0.100
058850	22	Avg	0.050	0.015	0.031	0.080	0.069	0.053	0.088	0.147
058850		Max	0.160	0.043	0.213	0.201	0.230	0.130	0.190	0.350
060060		Min	0.020	0.003	0.004	0.027	0.020	0.020	0.020	0.100
060060	17	Avg	0.146	0.019	0.072	0.470	0.059	0.072	0.150	0.893
060060		Max	0.580	0.045	0.468	3.020	0.160	0.200	0.520	6.370
061530		Min	0.010	0.007	0.003	0.013	0.020	0.020	0.020	0.100
061530	13	Avg	0.058	0.017	0.036	0.099	0.052	0.072	0.101	0.152
061530		Max	0.140	0.033	0.204	0.658	0.140	0.220	0.330	0.390
061560		Min	0.050	0.005	0.004	0.008	0.020	0.030	0.020	0.100
061560	6	Avg	0.102	0.017	0.013	0.131	0.060	0.150	0.000	0.347
061560		Max	0.260	0.036	0.038	0.648	0.130	0.300	0.290	0.930
061910		Min	0.050	0.012	0.020	0.029	0.020	0.050	0.030	0.100
061910	3	Avg	0.130	0.018	0.041	0.111	0.063	0.090	0.140	0.250
061910		Max	0.190	0.023	0.083	0.240	0.120	0.130	0.330	0.380
062120		Min	0.010	0.005	0.007	0.016	0.020	0.020	0.020	0.100
062120	17	Avg	0.058	0.013	0.037	0.123	0.045	0.066	0.111	0.213
062120		Max	0.230	0.040	0.113	0.730	0.090	0.170	0.280	0.450
062220		Min	0.010	0.003	0.003	0.008	0.020	0.020	0.020	0.100
062220	30	Avg	0.095	0.014	0.025	0.084	0.032	0.056	0.092	0.214
062220		Max	0.560	0.037	0.078	1.220	0.080	0.230	0.300	1.530
100360		Min	0.020	0.003	0.003	0.017	0.020	0.020	0.040	0.100
100360	14	Avg	0.719	0.040	0.054	0.295	0.059	0.327	0.255	0.565
100360		Max	5.780	0.118	0.127	1.740	0.240	1.530	0.810	2.280

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
101190		Min	0.010	0.012	0.023	0.066	0.020	0.020	0.120	0.140
101190	3	Avg	0.063	0.025	0.106	0.143	0.117	0.083	0.280	0.270
101190		Max	0.120	0.033	0.261	0.194	0.310	0.160	0.570	0.450
104100		Min	0.060	0.018	0.022	0.047	0.070	0.180	0.090	0.100
104100	1	Avg	0.060	0.018	0.022	0.047	0.070	0.180	0.090	0.100
104100		Max	0.060	0.018	0.022	0.047	0.070	0.180	0.090	0.100
112040		Min	0.050	0.015	0.021	0.031	0.020	0.050	0.050	0.100
112040	4	Avg	0.115	0.025	0.060	0.096	0.040	0.100	0.193	0.312
112040		Max	0.190	0.031	0.129	0.153	0.100	0.200	0.430	0.700
114140		Min	0.010	0.004	0.003	0.021	0.020	0.040	0.040	0.100
114140	5	Avg	0.170	0.037	0.012	0.174	0.058	0.176	0.248	0.738
114140		Max	0.580	0.083	0.028	0.543	0.170	0.440	0.920	2.370
120080		Min	0.010	0.002	0.003	0.004	0.020	0.020	0.020	0.100
120080	56	Avg	0.055	0.014	0.028	0.189	0.046	0.046	0.126	0.172
120080		Max	0.280	0.055	0.295	2.630	0.120	0.140	0.690	1.130
130340		Min	0.060	0.009	0.007	0.040	0.020	0.020	0.070	0.100
130340	4	Avg	0.230	0.030	0.049	0.117	0.057	0.395	0.215	0.393
130340		Max	0.470	0.053	0.124	0.339	0.160	0.770	0.410	0.720
130480		Min	0.030	0.009	0.008	0.028	0.020	0.020	0.050	0.100
130480	3	Avg	0.060	0.019	0.102	0.137	0.020	0.023	0.143	0.143
130480		Max	0.110	0.038	0.285	0.259	0.020	0.030	0.260	0.230
141160		Min	0.040	0.010	0.005	0.012	0.020	0.020	0.020	0.100
141160	4	Avg	0.185	0.074	0.034	0.192	0.085	0.045	0.145	0.355
141160		Max	0.340	0.218	0.065	0.606	0.240	0.070	0.260	0.790
141800		Min	0.170	0.018	0.008	0.032	0.090	0.140	0.050	0.510
141800	1	Avg	0.170	0.018	0.008	0.032	0.090	0.140	0.050	0.510
141800		Max	0.170	0.018	0.008	0.032	0.090	0.140	0.050	0.510
141980		Min	0.040	0.007	0.003	0.014	0.060	0.100	0.020	0.100
141980	3	Avg	0.090	0.026	0.027	0.101	0.113	0.497	0.160	0.373
141980		Max	0.160	0.045	0.066	0.275	0.190	1.110	0.390	0.920
143580		Min	0.050	0.012	0.018	0.028	0.020	0.060	0.090	0.100
143580	4	Avg	1.015	0.055	0.035	0.036	0.075	0.525	0.123	0.575
143580		Max	2.240	0.098	0.055	0.047	0.130	1.050	0.150	1.100
144740		Min	0.060	0.007	0.011	0.036	0.020	0.020	0.060	0.100
144740	8	Avg	0.114	0.020	0.047	0.172	0.061	0.088	0.121	0.174
144740		Max	0.200	0.038	0.141	0.813	0.150	0.170	0.240	0.380
146340		Min	0.050	0.009	0.008	0.021	0.020	0.020	0.020	0.100
146340	10	Avg	1.399	0.040	0.036	0.069	0.078	0.537	0.130	0.485
146340		Max	10.100	0.130	0.159	0.190	0.290	1.910	0.340	1.240

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
153421		Min	0.010	0.004	0.003	0.007	0.020	0.040	0.040	0.100
153421	3	Avg	0.030	0.020	0.011	0.021	0.027	0.070	0.060	0.257
153421		Max	0.040	0.045	0.017	0.029	0.030	0.090	0.080	0.420
154100		Min	0.050	0.013	0.013	0.016	0.030	0.080	0.170	0.100
154100	2	Avg	0.085	0.028	0.019	0.028	0.035	0.080	0.375	0.100
154100		Max	0.120	0.043	0.025	0.040	0.040	0.080	0.580	0.100
173120		Min	0.050	0.006	0.020	0.040	0.020	0.040	0.070	0.100
173120	4	Avg	0.173	0.020	0.046	0.340	0.140	0.510	0.170	0.378
173120		Max	0.490	0.049	0.098	1.050	0.450	1.760	0.260	1.210
190620		Min	0.070	0.019	0.033	0.163	0.020	0.020	0.140	0.100
190620	2	Avg	0.075	0.020	0.035	0.229	0.020	0.060	0.170	0.100
190620		Max	0.080	0.021	0.038	0.294	0.020	0.100	0.200	0.100
191260		Min	0.090	0.017	0.048	0.041	0.080	0.100	0.090	0.100
191260	2	Avg	0.140	0.032	0.131	0.128	0.135	0.125	0.210	0.100
191260		Max	0.190	0.046	0.214	0.214	0.190	0.150	0.330	0.100
193060		Min	0.040	0.009	0.022	0.102	0.020	0.050	0.090	0.100
193060	2	Avg	0.065	0.015	0.034	0.188	0.175	0.115	0.130	0.290
193060		Max	0.090	0.022	0.045	0.273	0.330	0.180	0.170	0.480
200010		Min	0.040	0.019	0.014	0.099	0.020	0.020	0.070	0.550
200010	2	Avg	0.105	0.026	0.015	0.154	0.055	0.155	0.145	0.620
200010		Max	0.170	0.032	0.016	0.209	0.090	0.290	0.220	0.690
200011		Min	0.070	0.017	0.003	0.044	0.020	0.020	0.070	0.100
200011	1	Avg	0.070	0.017	0.003	0.044	0.020	0.020	0.070	0.100
200011		Max	0.070	0.017	0.003	0.044	0.020	0.020	0.070	0.100
200045		Min	0.020	0.005	0.007	0.018	0.060	0.080	0.020	0.100
200045	2	Avg	0.020	0.006	0.010	0.019	0.090	0.135	0.030	0.100
200045		Max	0.020	0.007	0.012	0.020	0.120	0.190	0.040	0.100
200277		Min	0.030	0.010	0.009	0.018	0.020	0.060	0.050	0.100
200277	5	Avg	0.058	0.026	0.027	0.039	0.046	0.122	0.076	0.302
200277		Max	0.110	0.065	0.047	0.061	0.090	0.180	0.100	0.550
211320		Min	0.030	0.013	0.022	0.047	0.030	0.090	0.070	0.100
211320	2	Avg	0.050	0.016	0.037	0.095	0.035	0.100	0.105	0.100
211320		Max	0.070	0.019	0.052	0.142	0.040	0.110	0.140	0.100
220815		Min	0.030	0.003	0.003	0.009	0.020	0.070	0.020	0.100
220815	9	Avg	0.066	0.014	0.038	0.201	0.057	0.170	0.169	0.259
220815		Max	0.150	0.034	0.135	1.220	0.090	0.370	0.360	0.970
221325		Min	0.070	0.026	0.008	0.052	0.020	0.080	0.130	0.100
221325	4	Avg	0.083	0.028	0.018	0.121	0.078	0.185	0.368	0.153
221325		Max	0.090	0.030	0.027	0.292	0.140	0.250	0.670	0.310

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
230920	5	Min	0.030	0.011	0.004	0.021	0.020	0.020	0.020	0.100
230920		Avg	0.118	0.039	0.033	0.066	0.036	0.120	0.084	0.360
230920		Max	0.360	0.079	0.108	0.160	0.060	0.320	0.220	0.540
232240	1	Min	0.050	0.047	0.016	0.239	0.020	0.050	0.130	0.360
232240		Avg	0.050	0.047	0.016	0.239	0.020	0.050	0.130	0.360
232240		Max	0.050	0.047	0.016	0.239	0.020	0.050	0.130	0.360
232241	1	Min	0.030	0.010	0.006	0.033	0.020	0.170	0.080	0.100
232241		Avg	0.030	0.010	0.006	0.033	0.020	0.170	0.080	0.100
232241		Max	0.030	0.010	0.006	0.033	0.020	0.170	0.080	0.100
232570	2	Min	0.030	0.007	0.016	0.040	0.030	0.060	0.040	0.100
232570		Avg	0.045	0.010	0.018	0.900	0.080	0.125	0.095	0.100
232570		Max	0.060	0.013	0.019	1.760	0.130	0.190	0.150	0.100
232660	4	Min	0.020	0.010	0.003	0.008	0.020	0.020	0.030	0.100
232660		Avg	0.118	0.034	0.146	0.054	0.035	0.117	0.128	0.345
232660		Max	0.310	0.083	0.530	0.125	0.080	0.260	0.300	0.790
235340	3	Min	0.020	0.010	0.003	0.019	0.050	0.040	0.020	0.100
235340		Avg	0.070	0.020	0.013	0.032	0.093	0.187	0.070	0.287
235340		Max	0.130	0.035	0.021	0.050	0.150	0.470	0.120	0.660
241660	3	Min	0.070	0.015	0.034	0.042	0.020	0.020	0.070	0.100
241660		Avg	0.100	0.019	0.057	0.174	0.020	0.063	0.177	0.183
241660		Max	0.140	0.024	0.073	0.327	0.020	0.090	0.240	0.280
241840	7	Min	0.010	0.003	0.004	0.004	0.020	0.020	0.020	0.100
241840		Avg	0.076	0.015	0.021	0.085	0.077	0.109	0.094	0.264
241840		Max	0.340	0.045	0.053	0.405	0.390	0.450	0.300	0.440
242720	23	Min	0.090	0.020	0.010	0.031	0.020	0.020	0.020	0.100
242720		Avg	0.416	0.074	0.081	0.139	0.123	0.417	0.234	0.625
242720		Max	1.440	0.196	0.384	0.771	0.760	3.070	1.260	3.020
251460	10	Min	0.040	0.008	0.013	0.037	0.020	0.020	0.040	0.100
251460		Avg	0.106	0.041	0.039	0.121	0.088	0.091	0.143	0.313
251460		Max	0.350	0.110	0.069	0.269	0.310	0.160	0.290	1.250
260380	2	Min	0.020	0.007	0.023	0.057	0.070	0.020	0.070	0.100
260380		Avg	0.035	0.013	0.049	0.094	0.070	0.045	0.115	0.100
260380		Max	0.050	0.020	0.075	0.131	0.070	0.070	0.160	0.100
260560	3	Min	0.040	0.011	0.007	0.023	0.020	0.020	0.020	0.100
260560		Avg	0.063	0.014	0.029	0.244	0.030	0.047	0.090	0.163
260560		Max	0.090	0.020	0.044	0.532	0.050	0.070	0.140	0.290
270570	2	Min	0.060	0.016	0.032	0.048	0.030	0.060	0.130	0.100
270570		Avg	0.000	0.025	0.033	0.055	0.080	0.075	0.130	0.245
270570		Max	0.140	0.033	0.034	0.062	0.130	0.090	0.130	0.390

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
271340	10	Min	0.040	0.011	0.005	0.022	0.020	0.020	0.040	0.100
271340		Avg	0.118	0.029	0.032	0.303	0.070	0.097	0.165	0.201
271340		Max	0.320	0.073	0.149	2.480	0.320	0.380	0.650	0.450
281520	14	Min	0.010	0.004	0.005	0.019	0.020	0.020	0.020	0.050
281520		Avg	0.114	0.029	0.121	0.253	0.377	0.081	0.186	0.397
281520		Max	0.350	0.135	1.047	1.280	4.560	0.240	0.500	2.230
300240	1	Min	0.100	0.025	0.069	0.107	0.020	0.020	0.190	0.100
300240		Avg	0.100	0.025	0.069	0.107	0.020	0.020	0.190	0.100
300240		Max	0.100	0.025	0.069	0.107	0.020	0.020	0.190	0.100
312981	7	Min	0.010	0.006	0.003	0.028	0.020	0.060	0.050	0.100
312981		Avg	0.073	0.027	0.133	0.127	0.060	0.169	0.179	0.216
312981		Max	0.160	0.066	0.752	0.579	0.190	0.370	0.630	0.350
320720	6	Min	0.020	0.008	0.009	0.013	0.020	0.020	0.020	0.100
320720		Avg	0.112	0.019	0.071	0.169	0.112	0.147	0.167	0.205
320720		Max	0.280	0.033	0.237	0.624	0.350	0.350	0.270	0.530
320980	6	Min	0.030	0.007	0.017	0.013	0.020	0.060	0.020	0.100
320980		Avg	0.078	0.015	0.028	0.050	0.030	0.075	0.085	0.127
320980		Max	0.220	0.036	0.061	0.123	0.060	0.090	0.290	0.260
330860	7	Min	0.050	0.013	0.003	0.013	0.030	0.160	0.020	0.100
330860		Avg	0.100	0.028	0.053	0.065	0.121	0.281	0.111	0.696
330860		Max	0.150	0.058	0.301	0.211	0.320	0.630	0.330	3.100
331000	3	Min	0.090	0.020	0.005	0.083	0.020	0.070	0.070	0.110
331000		Avg	0.183	0.021	0.050	0.105	0.120	0.173	0.157	0.440
331000		Max	0.350	0.023	0.082	0.130	0.220	0.260	0.230	0.800
331220	3	Min	0.060	0.016	0.032	0.089	0.050	0.060	0.100	0.100
331220		Avg	0.217	0.027	0.056	0.146	0.107	0.113	0.113	2.963
331220		Max	0.490	0.041	0.102	0.213	0.160	0.160	0.140	8.260
332020	1	Min	0.070	0.065	0.028	0.390	0.100	0.040	0.170	0.360
332020		Avg	0.070	0.065	0.028	0.390	0.100	0.040	0.170	0.360
332020		Max	0.070	0.065	0.028	0.390	0.100	0.040	0.170	0.360
335140	5	Min	0.010	0.003	0.003	0.017	0.020	0.020	0.020	0.100
335140		Avg	0.050	0.028	0.012	0.035	0.060	0.122	0.076	0.258
335140		Max	0.080	0.074	0.037	0.085	0.130	0.310	0.200	0.630
335240	3	Min	0.100	0.016	0.024	0.122	0.020	0.050	0.150	0.210
335240		Avg	0.113	0.031	0.057	0.225	0.047	0.100	0.203	0.290
335240		Max	0.140	0.059	0.120	0.301	0.100	0.180	0.230	0.360
336500	2	Min	0.010	0.005	0.008	0.015	0.020	0.030	0.020	0.100
336500		Avg	0.035	0.010	0.011	0.024	0.035	0.070	0.090	0.155
336500		Max	0.060	0.014	0.013	0.033	0.050	0.110	0.160	0.210

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
340320	7	Min	0.020	0.005	0.015	0.024	0.020	0.060	0.070	0.100
340320		Avg	0.306	0.037	0.078	0.113	0.224	0.326	0.164	1.273
340320		Max	1.580	0.107	0.175	0.181	0.840	1.350	0.210	6.400
341180	7	Min	0.020	0.008	0.003	0.013	0.020	0.040	0.030	0.100
341180		Avg	0.184	0.020	0.005	0.106	0.051	0.121	0.139	0.551
341180		Max	1.010	0.044	0.009	0.456	0.110	0.310	0.290	2.750
342500	3	Min	0.010	0.015	0.007	0.021	0.040	0.030	0.030	0.100
342500		Avg	0.037	0.022	0.040	0.071	0.123	0.117	0.103	0.213
342500		Max	0.060	0.034	0.098	0.149	0.220	0.210	0.220	0.440
343310	9	Min	0.010	0.006	0.003	0.012	0.020	0.030	0.020	0.100
343310		Avg	0.051	0.019	0.014	0.053	0.063	0.083	0.093	0.334
343310		Max	0.130	0.038	0.058	0.164	0.110	0.140	0.250	1.830
343460	4	Min	0.050	0.008	0.007	0.032	0.020	0.050	0.040	0.100
343460		Avg	0.063	0.017	0.035	0.079	0.193	0.147	0.087	0.220
343460		Max	0.090	0.030	0.074	0.160	0.660	0.310	0.160	0.350
343560	7	Min	0.040	0.013	0.005	0.013	0.020	0.020	0.040	0.100
343560		Avg	0.093	0.036	0.215	0.085	0.069	0.131	0.313	0.287
343560		Max	0.170	0.092	1.390	0.224	0.290	0.420	1.680	1.080
344160	6	Min	0.020	0.012	0.004	0.010	0.020	0.050	0.050	0.100
344160		Avg	0.053	0.018	0.041	0.059	0.110	0.125	0.103	0.130
344160		Max	0.100	0.024	0.109	0.100	0.520	0.310	0.240	0.240
350700	5	Min	0.020	0.007	0.012	0.013	0.020	0.040	0.020	0.100
350700		Avg	0.048	0.021	0.025	0.053	0.072	0.052	0.078	3.684
350700		Max	0.110	0.048	0.043	0.158	0.120	0.060	0.110	17.920
350880	2	Min	0.050	0.014	0.029	0.075	0.020	0.020	0.100	0.100
350880		Avg	0.050	0.015	0.035	0.102	0.020	0.035	0.170	0.100
350880		Max	0.050	0.015	0.042	0.130	0.020	0.050	0.240	0.100
361760	7	Min	0.010	0.003	0.003	0.008	0.020	0.020	0.020	0.100
361760		Avg	0.076	0.015	0.014	0.051	0.091	0.201	0.080	0.327
361760		Max	0.130	0.026	0.033	0.190	0.310	0.820	0.160	0.950
364900	9	Min	0.020	0.010	0.004	0.010	0.020	0.070	0.030	0.100
364900		Avg	0.129	0.026	0.027	0.041	0.102	0.209	0.082	0.859
364900		Max	0.450	0.082	0.079	0.066	0.460	0.630	0.160	4.930
367160	4	Min	0.010	0.007	0.003	0.007	0.020	0.020	0.020	0.100
367160		Avg	0.058	0.016	0.009	0.047	0.020	0.050	0.080	0.147
367160		Max	0.150	0.036	0.016	0.097	0.020	0.090	0.160	0.290
371740	3	Min	0.020	0.018	0.044	0.071	0.020	0.020	0.150	0.100
371740		Avg	0.067	0.029	0.073	0.153	0.020	0.110	0.277	0.110
371740		Max	0.120	0.049	0.123	0.228	0.020	0.220	0.470	0.130

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
372580	3	Min	0.050	0.011	0.012	0.022	0.020	0.070	0.050	0.100
372580		Avg	0.067	0.017	0.019	0.036	0.063	0.080	0.127	0.293
372580		Max	0.090	0.020	0.024	0.045	0.150	0.090	0.200	0.440
380200	10	Min	0.010	0.006	0.003	0.010	0.020	0.020	0.020	0.100
380200		Avg	0.081	0.017	0.035	0.053	0.050	0.117	0.109	0.181
380200		Max	0.190	0.063	0.175	0.109	0.130	0.390	0.410	0.850
380201	11	Min	0.010	0.004	0.003	0.008	0.020	0.020	0.020	0.090
380201		Avg	0.055	0.011	0.006	0.047	0.035	0.095	0.045	0.220
380201		Max	0.170	0.017	0.012	0.298	0.070	0.240	0.100	0.750
380202	3	Min	0.030	0.010	0.012	0.041	0.020	0.040	0.050	0.100
380202		Avg	0.050	0.016	0.036	0.064	0.073	0.063	0.300	0.160
380202		Max	0.060	0.024	0.068	0.101	0.110	0.100	0.720	0.280
380840	16	Min	0.020	0.003	0.003	0.009	0.020	0.020	0.020	0.100
380840		Avg	0.067	0.018	0.033	0.059	0.042	0.076	0.076	0.240
380840		Max	0.190	0.064	0.239	0.270	0.220	0.170	0.260	1.340
381020	12	Min	0.010	0.004	0.003	0.007	0.020	0.030	0.020	0.100
381020		Avg	0.134	0.049	0.029	0.184	0.045	0.097	0.112	0.457
381020		Max	0.800	0.342	0.150	1.190	0.120	0.250	0.340	2.240
381120	14	Min	0.010	0.003	0.003	0.008	0.020	0.020	0.020	0.100
381120		Avg	0.088	0.018	0.030	0.053	0.049	0.111	0.096	0.229
381120		Max	0.550	0.045	0.089	0.173	0.170	0.610	0.280	0.870
381780	4	Min	0.030	0.010	0.013	0.027	0.020	0.020	0.050	0.100
381780		Avg	0.075	0.020	0.039	0.051	0.210	0.380	0.073	0.565
381780		Max	0.190	0.033	0.089	0.074	0.520	0.960	0.090	1.070
391520	1	Min	0.100	0.020	0.237	0.138	0.200	0.020	0.250	0.100
391520		Avg	0.100	0.020	0.237	0.138	0.200	0.020	0.250	0.100
391520		Max	0.100	0.020	0.237	0.138	0.200	0.020	0.250	0.100
392940	3	Min	0.010	0.005	0.003	0.028	0.020	0.040	0.020	0.100
392940		Avg	0.037	0.009	0.017	0.071	0.033	0.113	0.097	0.267
392940		Max	0.050	0.012	0.042	0.129	0.060	0.160	0.150	0.410
394200	6	Min	0.030	0.006	0.008	0.018	0.020	0.020	0.020	0.100
394200		Avg	0.112	0.016	0.021	0.054	0.037	0.123	0.138	0.302
394200		Max	0.270	0.027	0.043	0.122	0.070	0.290	0.250	0.760
430060	7	Min	0.040	0.012	0.009	0.017	0.020	0.020	0.020	0.100
430060		Avg	0.313	0.079	0.118	0.040	0.039	0.091	0.077	0.340
430060		Max	1.450	0.376	0.723	0.074	0.110	0.180	0.130	0.790
430061	2	Min	0.020	0.011	0.005	0.040	0.020	0.020	0.080	0.100
430061		Avg	0.095	0.027	0.064	0.075	0.040	0.035	0.130	0.100
430061		Max	0.170	0.044	0.124	0.110	0.060	0.050	0.180	0.100

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
430880		Min	0.040	0.011	0.008	0.035	0.080	0.080	0.070	0.100
430880	1	Avg	0.040	0.011	0.008	0.035	0.080	0.080	0.070	0.100
430880		Max	0.040	0.011	0.008	0.035	0.080	0.080	0.070	0.100
440040		Min	0.050	0.014	0.013	0.023	0.020	0.050	0.020	0.100
440040	5	Avg	0.064	0.020	0.059	0.072	0.056	0.082	0.146	0.856
440040		Max	0.100	0.030	0.214	0.153	0.110	0.160	0.240	3.580
450425		Min	0.010	0.003	0.003	0.008	0.020	0.020	0.020	0.020
450425	44	Avg	0.094	0.022	0.023	0.083	0.052	0.116	0.110	0.338
450425		Max	0.480	0.340	0.167	1.200	0.200	1.770	1.010	3.010
452180		Min	0.050	0.010	0.003	0.022	0.020	0.020	0.050	0.100
452180	8	Avg	0.102	0.023	0.050	0.244	0.056	0.068	0.155	0.472
452180		Max	0.160	0.040	0.140	1.450	0.200	0.140	0.420	2.070
453800		Min	0.010	0.007	0.003	0.011	0.020	0.020	0.030	0.100
453800	14	Avg	0.107	0.022	0.046	0.135	0.059	0.159	0.198	0.294
453800		Max	0.320	0.067	0.205	0.539	0.190	0.460	0.920	0.960
455350		Min	0.020	0.007	0.005	0.027	0.020	0.020	0.050	0.100
455350	19	Avg	0.352	0.066	0.046	0.350	0.056	0.120	0.483	0.280
455350		Max	2.250	0.455	0.187	3.200	0.130	0.380	3.780	1.060
460120		Min	0.090	0.017	0.023	0.405	0.640	1.300	0.650	0.990
460120	1	Avg	0.090	0.017	0.023	0.405	0.640	1.300	0.650	0.990
460120		Max	0.090	0.017	0.023	0.405	0.640	1.300	0.650	0.990
460280		Min	0.030	0.003	0.003	0.006	0.020	0.020	0.020	0.100
460280	5	Avg	0.058	0.014	0.163	0.102	0.046	0.068	0.174	0.100
460280		Max	0.120	0.036	0.788	0.458	0.080	0.140	0.750	0.100
470100		Min	0.020	0.008	0.004	0.009	0.020	0.050	0.020	0.100
470100	2	Avg	0.045	0.013	0.021	0.033	0.020	0.050	0.055	0.100
470100		Max	0.070	0.018	0.038	0.057	0.020	0.050	0.090	0.100
491410		Min	0.010	0.004	0.003	0.007	0.020	0.020	0.030	0.100
491410	5	Avg	0.028	0.008	0.008	0.025	0.068	0.066	0.054	0.192
491410		Max	0.050	0.017	0.014	0.048	0.260	0.160	0.090	0.500
501860		Min	0.060	0.006	0.003	0.010	0.020	0.090	0.020	0.100
501860	3	Avg	0.087	0.012	0.010	0.044	0.067	0.147	0.073	0.280
501860		Max	0.110	0.023	0.019	0.104	0.150	0.180	0.160	0.450
512800		Min	0.050	0.010	0.008	0.043	0.020	0.060	0.090	0.100
512800	3	Avg	0.153	0.013	0.033	0.630	0.040	0.123	0.247	0.253
512800		Max	0.280	0.014	0.058	1.730	0.070	0.160	0.540	0.390
513640		Min	0.020	0.008	0.011	0.012	0.070	0.080	0.030	0.150
513640	2	Avg	0.035	0.012	0.034	0.038	0.080	0.080	0.080	0.265
513640		Max	0.050	0.016	0.058	0.063	0.090	0.080	0.130	0.380

Site Number	No. of DA's		Ca	Mg	K	Na	NH4	NO3	Cl	SO4
						mg/ L				
513700	11	Min	0.020	0.006	0.003	0.011	0.020	0.020	0.020	0.100
513700		Avg	0.049	0.016	0.042	0.062	0.055	0.098	0.105	0.208
513700		Max	0.160	0.060	0.187	0.237	0.160	0.280	0.300	0.410
520680	4	Min	0.040	0.008	0.008	0.035	0.020	0.020	0.050	0.100
520680		Avg	0.067	0.020	0.020	0.063	0.045	0.087	0.112	0.205
520680		Max	0.120	0.031	0.044	0.094	0.120	0.170	0.190	0.290
520820	13	Min	0.010	0.003	0.003	0.006	0.020	0.020	0.020	0.100
520820		Avg	0.075	0.039	0.029	0.143	0.060	0.067	0.152	0.233
520820		Max	0.320	0.330	0.110	1.120	0.180	0.200	0.470	0.920
520860	4	Min	0.020	0.003	0.003	0.006	0.020	0.030	0.020	0.100
520860		Avg	0.080	0.024	0.016	0.053	0.047	0.060	0.050	0.220
520860		Max	0.200	0.071	0.025	0.093	0.080	0.130	0.090	0.370
530190	2	Min	0.040	0.021	0.026	0.104	0.020	0.020	0.320	0.260
530190		Avg	0.075	0.039	0.062	0.229	0.020	0.035	0.520	0.290
530190		Max	0.110	0.056	0.097	0.355	0.020	0.050	0.720	0.320

NC-141 SITE DESCRIPTION QUESTIONNAIRE

____
Agency, Organization or Institution

A. SITE IDENTIFICATION

1. Station__________ 2. County__________ 3. State__________

4. Latitude____°____' 5. Longitude____°____'____" 6. Elevation____(m)

7. Name of Supervisory Official______________________________

Alternate______________________________

8. Mailing Address______________________________
(number -- street) *(city -- state)* *(zip code)*

9. Phone____/__________ ____/__________
(commercial) *(FTS)*

B. LOGISTICS

1. Is road access to proposed site in summer: ____Good, ____Fair, ____Poor? and winter: ____Good, ____Fair, ____Poor?

2. Type of road surface?______________________________

3. How far from the road will collector be sited?__________(m)

4. How close can a vehicle approach the collector?__________(m)

5. What electrical power is available on site?__________(Volts)__________(Amps)

If none, how soon will it be provided?__________
(date)

6. Is there adequate security against vandalism, etc? ________(Yes)________(No)

7. Are there any special logistical problems? Please describe:__________

____

____

C. EQUIPMENT ON HAND

1. Raingage: None__________ Recording__________ Non-Recording__________
   Weighing __________ Tipping Bucket__________ Other__________
   Opening__________(cm) Manufacturer__________ Model__________

   Distance__________(m)

2. Wind: None__________ Speed__________ Direction__________ Distance__________(m)

   Recording__________ Non-Recording__________ Manufacturer__________

   Model__________ Height above ground__________(m)

3. pH Meter: None_____ Manufacturer__________ Model__________

4. Conductivity Meter: None__________ Manufacturer__________

   Model__________

5. Available Lab Space: None_____ Good_____ Fair_____ Poor_____

   Distance__________(km)

6. Other related equipment (please list):__________

   ____

D. BACKGROUND DATA

1. Precipitation at the site:

   Yes_____ Years_____ Annual Precipitation__________mm

   No_____ Nearest gage__________(km) Years__________

   Annual rain__________(mm) Annual snow__________(cm)

2. Wind at site: Yes____ No____ Years_____ Distance to nearest measurement__________(km)
   (Please attach wind rose if available.)

3. If air quality or precipitation chemistry data available at or near the site, please describe:

   ____

   ____

   ____

E. TOPOGRAPHY

1. Ground slope at site: Direction from sampler____ Amount +/-____________%

2. Soil type: within 10 m of site__________, within 1 km__________________

% Cultivated____________, % Orchard___________, % Lawn________________

% Pasture_______________, % Forest_____________, % Other_______________

within 1/4 section containing site.

(Please attach standard soil analysis if available.)

3. Tall objects in area:

A. Trees ___________________________ Max. Height ____________ (m)
Species

Distance ________________________ (m) Direction ______________

B. Buildings ______________________ Height __________________ (m)
Type

Use: ______________________________ Distance ______ Direction ____

C. Other (eg overhead wires, masts, etc.)

(1) Object ____________________, Height ____________________(m)
Direction ____________________, Distance ____________________(m)

(2) Object ____________________, Height ____________________(m)
Direction ____________________, Distance ____________________(m)

(3) Object ____________________, Height ____________________(m)
Direction ____________________, Distance ____________________(m)

F. CIVILIZATION

1. Large highways (expressways): Distance______(km, m) Route #________________
   Direction from sampler___________.
2. Other paved roads: Distance_________(km, m) Direction from sampler_________
   traffic: Heavy_________, Medium__________, Light__________.
3. Unpaved road: Distance______________(km, m) Direction from sampler_________
   traffic: Heavy_________, Medium__________, Light__________.
4. Parking lot: Distance _______________(km, m) Direction from sampler_________
   Unpaved___________ Surface material__________ Use: continuous______________
   intermittent______ car volume________________ large truck volume___________
5. Lake/river or rail traffic: Distance_______(km, m) Direction from sampler____
   barge_________, lake steamer________, ocean vessels_________, rail___________
   traffic: Heavy_________, Medium___________, Light__________.
6. Airport(s): Distance______(km, m) Direction from sampler________
   traffic: Heavy_________, Medium___________, Light__________.
7. Stationary sources:
   Power plant(s): Distance________(km) Direction from sampler____ Fuel__________
   Electrical capacity_________________(KW_e, MW_e)
   Light industry: Distance________(km) Direction from sampler____ Product_______
   Heavy industry: Distance________(km) Direction from sampler____ Product_______
8. Other sources: Significant agricultural operations: Distance____________ (km, m)
   Direction from sampler_______ Other (please describe)__________________________
   ____
   Distance__________(km, m) Direction from sampler______________.

G. OTHER

It would be very useful for the Site Selection and Certification Subcommittee to have one or more of the following submitted with the questionnaire.

1. Topographic map, 1:24,000, revision year____________ not available__________
2. Topographic map, 1:250,000, revision year___________ not available__________
3. Aerial photograph, 1:1200, year_____________________ not available__________
4. Photos of the site in the 8 directions.

The site and items noted in Section F should be indicated on the figures.

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

Supplemental Site Information Questionnaire

1. Check those meteorological instruments co-located (within 20 meters) with the NADP sampler. This equipment is not required for participation in NADP. The information will be used to answer requests for information about additional data collected at NADP sites.

___ Wind Run (transport)
___ Sonic Anemometer (wind speed)
___ Cup Anemometer (wind speed)
___ Propeller Anemometer (wind speed)
___ Hot wire Anemometer (wind speed)
___ Wind Vane (direction)
___ Pitot Tube (wind speed)
___ Ceilometer
___ Transmissiometer
___ Fog Detector
___ Sight Clinometer
___ Rawinsonde
___ Evaporimeter
___ Evaporation Pan
___ Dew Point Temperature (LiCl)
___ Dew Point Temperature (cooled mirror)
___ Relative Humidity
___ Hair Hygrometer
___ Psychrometer
___ Dial Hygrometer
___ Wet Bulb Thermometer
___ Tipping Bucket Rain Gage
___ Snow Gage
___ Rate of Rainfall Gage
___ Standard US Weather Bureau 8" Rain Gage
___ Alter Windshield
___ Precipitation Detector
___ Barograph

___ Aneroid Barometer
___ Mercurial Barometer
___ Sunshine Duration (Campbell Stokes)
___ Pyranometer
___ Radiometer, Spot
___ Radiometer, Integrated
___ Pyreheliometer
___ Shadowband
___ Net Radiometer
___ Thermograph
___ Max-Min Thermometer
___ Hygrothermograph
___ Tower (3 meter)
___ Tower (10 meter)
___ Tower (Other ____meters)
___ Soil Moisture
___ Snow Depth (pillow)
___ Snow Depth (core)
___ Lightning Count Recorder
___ Potential Gradient Recorder
___ Other
____
____
____
____
____

2. a. Check those aerosol samplers co-located (within 20 meters) with the NADP Sampler. Not required for NADP membership.

___ Inertial Cascade Impactor
___ Integrating Nephelometer
___ Hi Volume Filter
___ Other
____
____
____
____
____

___ Dichotomous Particulate Sampler
___ Inhalable Particulate Sampler
___ Condensation Nucleous Counter
___ Aerosol Size Analyzer
___ Membrane Filter & Vacuum Pump

b. What chemical constituents on the filters are analyzed? ______________________
____
____

c. By what analytical technique? ______________________________
____
____

3. Check those gas measurements made within 20 meters of your NADP collector. Not required for NADP membership.

Continuous Measurements

___ SO_2
___ NO
___ NO_x
___ HNO_3
___ O_3
___ H_2SO_4
___ Other
____
____
____

Bubbler Gas Sampler

___ SO_2
___ NO_2
___ H_2S
___ NH_3
___ O_3
___ Aliphatic Aldehydes
___ CO

4. Associated acid rain effects research going on at the site (within 0.5 km radius). Not required for NADP membership.

____
____
____
____
____
____
____
____
____
____

5. Does a calibrated watershed exist?

Area____________________hectares

Slopes____________________

Covertype____________________

Method of flow gaging?

Kinds of chemical analyses performed and method?

6. Person who filled out this form:

NADP Site________________________________

Name________________________________

Position________________________________

Phone #________________________________

Address________________________________

____

____

SECTION 9
Quality Assurance Report
NADP/NTN Deposition Monitoring

Section 9 is a reproduction of a report released in May 1987 documenting the quality assurance activities in the laboratory operations of the NADP/NTN monitoring network from 1978 to 1983. The page numbers (173-217) at the bottom of the pages have been added to conform with the pagination scheme of the present report.

SECTION 9
Quality Assurance Report
NADP/NTN Deposition Monitoring

Laboratory Operations
Central Analytical Laboratory
July 1978 through December 1983

prepared by Jacqueline M. Lockard
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Illinois State Water Survey
2204 Griffith Drive
Champaign, Illinois 61820-7495
May 1987

ACKNOWLEDGEMENTS

This Quality Assurance Report was prepared under the general direction of Mark E. Peden, Laboratory Manager for the Central Analytical Laboratory (CAL) of the National Atmospheric Deposition Program (NADP)/National Trends Network (NTN). The analytical data summarized in this report were produced by the laboratory personnel listed in Section II. Most of the figures were prepared by the Communications Unit of the Illinois State Water Survey. The statistical analyses and computer generated plots were capably prepared by Peg A. Folta. Randall K. Stahlhut was responsible for most of the network history summaries. I wish to thank Lacie L. Jeffers for the secretarial support she provided during the preparation of this report. I also extend my appreciation to Van Bowersox and the Data Management staff of the CAL for their technical support. Recommendations made by NADP Subcommittee #2 have been influential in the development of the overall quality assessment program at the CAL and we gratefully acknowledge the continuing support of its members. The final note of thanks goes to David Bigelow, NADP/NTN Quality Assurance Manager; Douglas L. Sisterson, Chairman NADP Subcommittee #2; Richard G. Semonin, Chief of the Illinois State Water Survey; Gary J. Stensland, CAL Director; and the members of the NADP/NTN Quality Assurance Steering Committee, whose assistance as reviewers of this report resulted in the document you now read.

This report is the second in a series of Quality Assurance Reports documenting the quality assurance activities in the NADP/NTN monitoring network through 1983.

I. INTRODUCTION

The first Quality Assurance Report for the Central Analytical Laboratory (CAL) (1) of the National Atmospheric Deposition Program (NADP) was published in 1980. It detailed the beginnings and the goals of the quality assessment program being developed for the laboratory. This report incorporates the data from that original report with quality assurance data from the years 1980 through 1983. Also included are discussions of changes to the program that have occurred as it has been refined throughout the six-year period.

The first set of data presented in this report resulted from the routine analysis of laboratory blanks (Section III). These blank samples include bucket leachates, filter leachates, and deionized water. The data provide information that can be used to assess the potential contribution of sample collection and processing to the analyte concentrations found in the network samples. The CAL quality assurance program utilizes quality control check (QCC) samples (Section IV) to quantify analytical bias and precision. An additional estimate of precision is achieved through replicate sample analyses (Section IV). The validity of these bias and precision estimates is supported by the performance of the CAL in external quality assurance audits and round robin testing programs (Section VI) sponsored by both state and federal government agencies in the United States, and the governments of Canada and several European countries. Finally, an assessment of how well the CAL succeeded during this six-year period in meeting its original goals is presented in the summary (Section VII).

II. LABORATORY QUALITY ASSURANCE PROGRAM

A. GENERAL DESCRIPTION

The published report of 1980 presented a complete description of the laboratory quality assurance program at the CAL. This program experienced relatively few changes between 1978 and 1983. The methods documented by Stensland, et al. (1) continued to be used throughout the six-year period. This section addresses the changes that have occurred since the 1980 report. These include changes in sample processing, quality control sample analyses, detection limits, and personnel.

The sample processing flowchart represented by Figure II-1 changed to that depicted in Figure II-2 in early 1981. Starting in 1981, the filters were no longer dried and stored and the wet bucket was no longer reweighed. A single 60 mL aliquot was taken after filtration for sample analysis. If sufficient sample remained, a second 60 mL aliquot was taken after filtration for archiving (refrigerated storage). The remainder of the sample, as well as the filter, was then discarded.

The number of quality control samples analyzed increased steadily over this six-year period. Internal formulations were developed for quality control check (QCC) samples to monitor pH and specific conductance measurements. These samples were analyzed at a frequency of two QCC samples for every 25-30 pH measurements and two different QCC samples for every 25-30 specific conductance measurements. Dilutions of mineral and nutrient series concentrates provided by the United States Environmental Protection Agency-EMSL, Cincinnati, Ohio, were used to monitor the accuracy of the analyses of the remaining parameters measured in the program. Early in the development of the quality assurance program the frequency of analysis of these quality control check samples was established. The result was a minimum of one quality control check sample analyzed with each group of twelve precipitation samples.

New instrumentation resulted in improvements in the method detection limits (MDLs). A further change in the MDLs occurred in 1981 when they were redefined from two to three times the baseline or instrument noise. The baseline or instrumentation noise was determined either by direct measurement of the noise through use of a strip chart recorder or by using the standard deviation that resulted from a minimum of ten analyses of deionized water blanks. This redefinition of the term made the CAL usage of MDL consistent with that recommended by the American Chemical Society (ACS). The MDLs for the years 1979 through 1983 are listed in Table II-1. The data published by the NADP/NTN network reflect the MDLs that existed during the time of the analysis.

B. DATA AVAILABILITY

The data presented in this report have been verified by either a double entry procedure or a visual check. The data have been stored in the CAL data base and are available upon request from the Director.

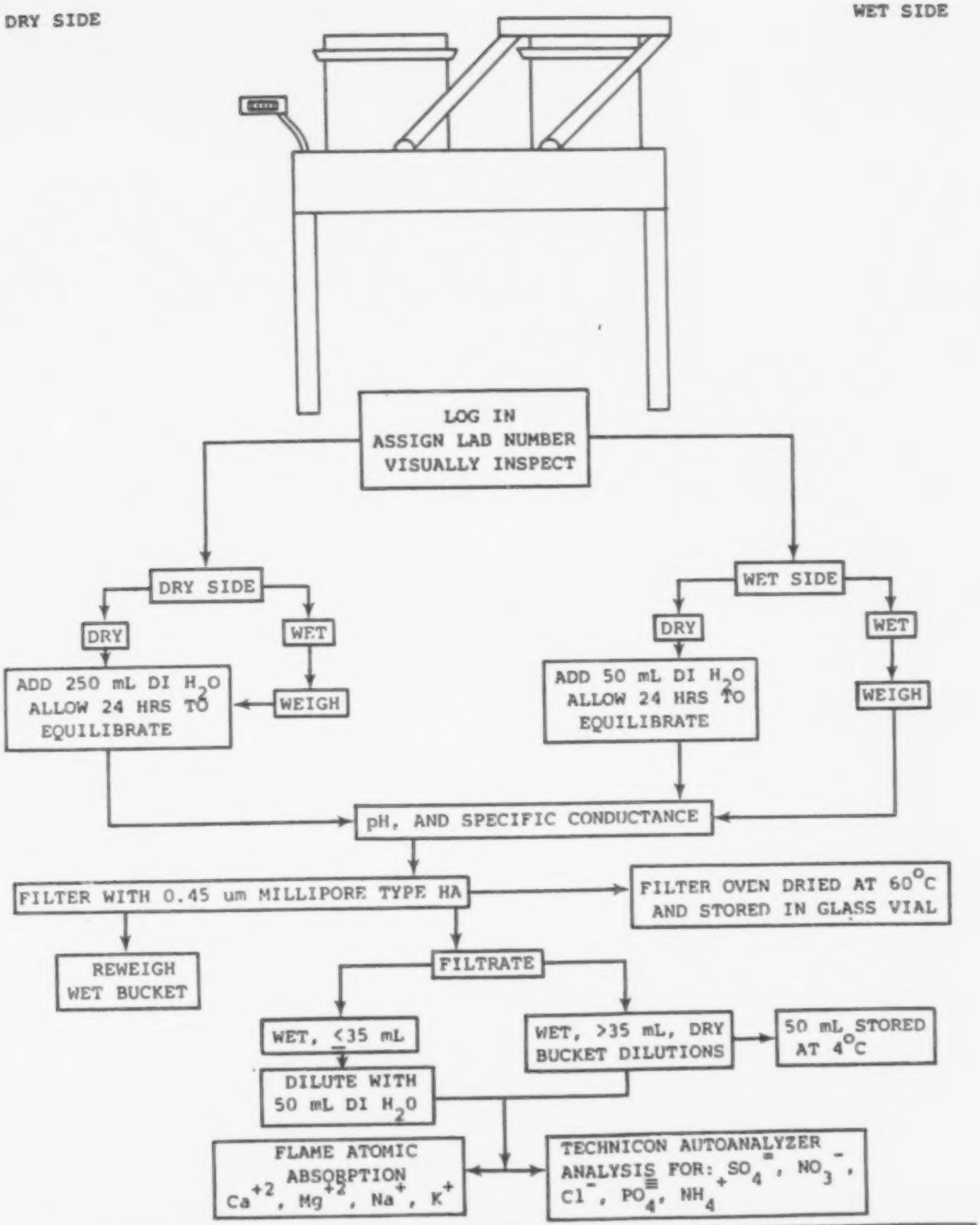

DRY SIDE
WET SIDE
LOG IN
ASSIGN LAB NUMBER
VISUALLY INSPECT
DRY SIDE
DRY
WET
ADD 250 mL DI H_2O ALLOW 24 HRS TO EQUILIBRATE
WEIGH
WET SIDE
DRY
WET
ADD 50 mL DI H_2O ALLOW 24 HRS TO EQUILIBRATE
WEIGH
pH, AND SPECIFIC CONDUCTANCE
FILTER WITH 0.45 um MILLIPORE TYPE HA
FILTER OVEN DRIED AT 60°C AND STORED IN GLASS VIAL
REWEIGH WET BUCKET
FILTRATE
WET, ≤35 mL
WET, >35 mL, DRY BUCKET DILUTIONS
50 mL STORED AT 4°C
DILUTE WITH 50 mL DI H_2O
FLAME ATOMIC ABSORPTION Ca^{+2}, Mg^{+2}, Na^+, K^+
TECHNICON AUTOANALYZER ANALYSIS FOR: $SO_4^=$, NO_3^-, Cl^-, $PO_4^{\equiv}$, NH_4^+

FIGURE II-1. Sample processing flowchart for 1978 through 1980.

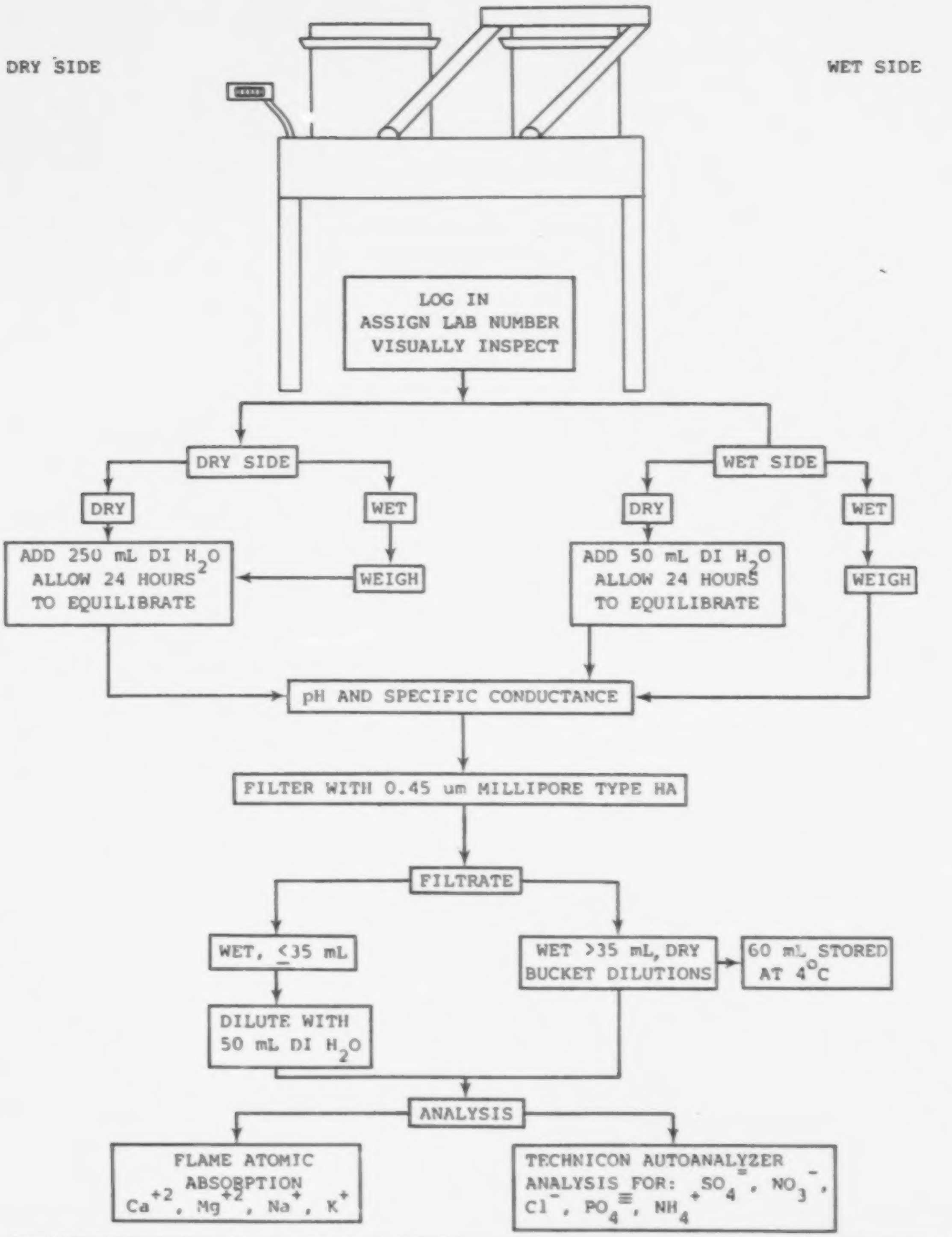

DRY SIDE
WET SIDE
LOG IN
ASSIGN LAB NUMBER
VISUALLY INSPECT
DRY SIDE
WET SIDE
DRY
WET
DRY
WET
ADD 250 mL DI H_2O
ALLOW 24 HOURS
TO EQUILIBRATE
WEIGH
ADD 50 mL DI H_2O
ALLOW 24 HOURS
TO EQUILIBRATE
WEIGH
pH AND SPECIFIC CONDUCTANCE
FILTER WITH 0.45 um MILLIPORE TYPE HA
FILTRATE
WET, ≤35 mL
WET >35 mL, DRY
BUCKET DILUTIONS
60 mL STORED
AT 4°C
DILUTE WITH
50 mL DI H_2O
ANALYSIS
FLAME ATOMIC
ABSORPTION
Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}
TECHNICON AUTOANALYZER
ANALYSIS FOR: $SO_4^{=}$, NO_3^{-},
Cl^{-}, $PO_4^{\equiv}$, NH_4^{+}

FIGURE II-2. Sample processing flowchart for 1981 through 1983.

TABLE II-1 **Method Detection Limits for the Analysis of Precipitation Samples from 1979 through 1983.**

Analyte	Method[a]	Method Detection Limit (MDL) mg/L	Dates
Calcium	Flame Atomic Absorption	0.02 0.009	1/79 - 10/80 10/80 - 12/83
Magnesium	Flame Atomic Absorption	0.002 0.003	1/79 - 10/80 10/80 - 12/83
Sodium	Flame Atomic Absorption	0.004 0.003	1/79 - 10/80 10/80 - 12/83
Potassium	Flame Atomic Absorption	0.004 0.003	1/79 - 10/80 10/80 - 12/83
Ammonium	Automated Phenate, Colorimetric	0.02	1/79 - 12/83
Sulfate	Automated Methyl Thymol Blue, Colorimetric	0.10	1/79 - 12/83
Nitrate-Nitrite	Automated Cadmium Reduction, Colorimetric	0.02	1/79 - 12/83
Chloride	Automated Ferricyanide, Colorimetric	0.05 0.02	1/79 - 3/81 3/81 - 12/83
Ortho-phosphate	Automated Ascorbic Acid, Colorimetric	0.003	1/79 - 12/83

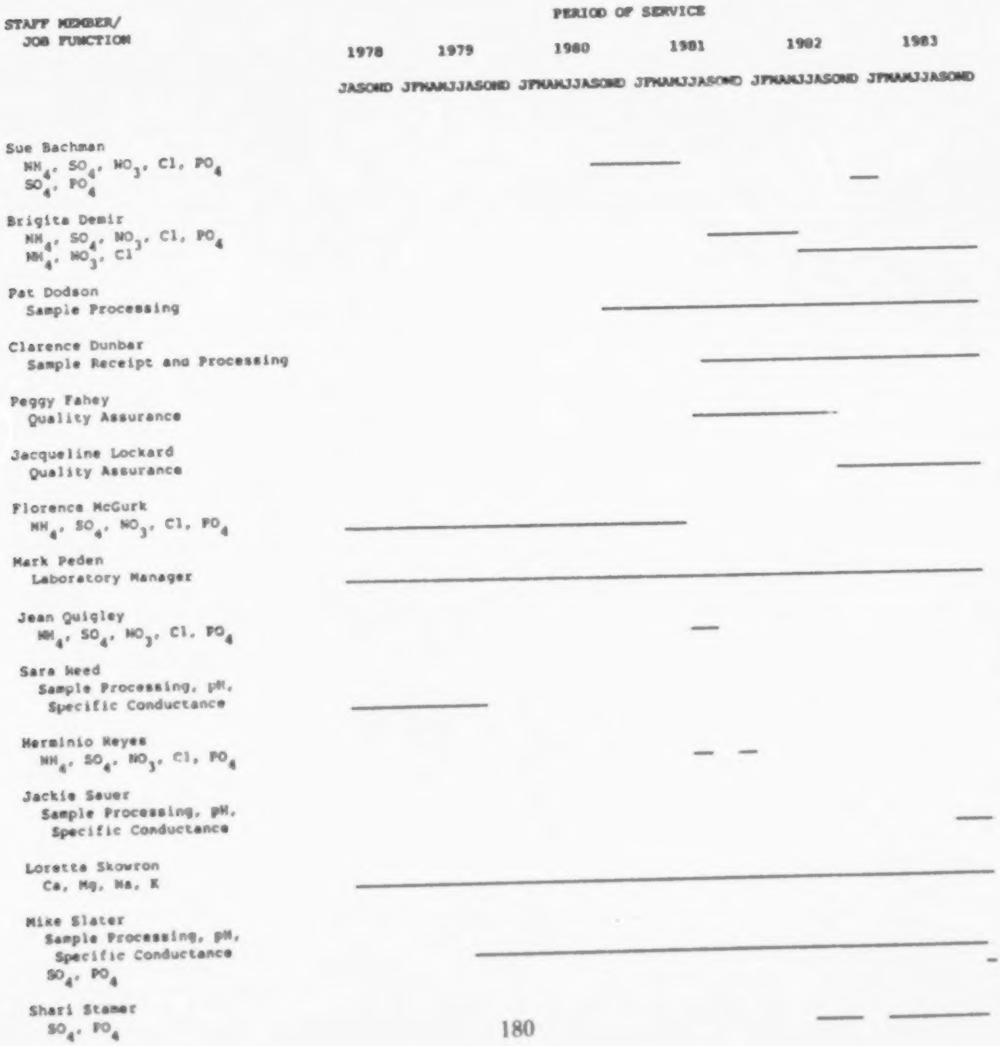
---

a. For a complete method description, see NADP Quality Assurance Report - Central Analytical Laboratory, Jan. 1979-Dec. 1979, Stensland, et al., 1980.

C. LABORATORY PERSONNEL

The educational and training requirements for the laboratory staff and the general laboratory procedures remain unchanged since the 1980 Quality Assurance Report. There were personnel changes during the first six years of the program including staff additions, replacements for departing analysts, and job reassignments. Until June 1981 the quality assurance program for the laboratory was directed by the laboratory manager. In June, the position of quality assurance specialist was created and the responsiblity for the laboratory QA program given to the person filling that position. Table II-2 alphabetically lists the laboratory personnel who participated in the project during this time period. It also includes a brief description of each staff member's primary function within the program and the duration of their employment as part of the CAL.

TABLE II-2 Central Analytical Laboratory (CAL) Personnel Summary (1978-1983)
Analytical Staff Only.



III. LABORATORY BLANK DATA

The data presented in this section were generated from the analysis of the deionized (DI) water used by the laboratory, DI water left in a clean sample collection bucket for 24 hours, and DI water that had been filtered through a preleached 0.45 um Millipore (HAWP) filter. All of the data obtained were used to define the potential contributions of the collection vessel and the sample processing procedures to the measured analyte concentrations in precipitation. The procedures used to obtain each blank sample type are described in this section and the resultant analytical data are presented graphically or in tables.

A. BUCKET LEACHATES

At the start of the program the sample collection buckets were cleaned by hand. This cleaning included scrubbing of the bucket using a natural sponge to remove any particulates adhering to the plastic surface followed by repeated rinsings with DI until the specific conductance of the rinse water measured less than 2 uS/cm. In May 1982 the procedure was changed. Since that time, the buckets have been emptied of sample, wiped free of particulate matter, then washed in a commercial dishwasher. The wash cycle used city tap water and the three rinse cycles, deionized water. Once washed and rinsed, the buckets were shaken free of excess water and immediately placed in plastic bags and sealed. No detergent was ever utilized in any of the cleaning procedures.

The bucket lids contain a butadiene rubber gasket that assures a watertight seal of the bucket once the lid has been securely hammered in place. These gaskets may be either black or white, the only difference being the addition of carbon black to the molten rubber to produce the color. Although this rubber compound is relatively inert, the releasing agent used in the molds in which the gaskets are formed contains calcium, magnesium and zinc. Also as part of the extrusion process, the gasket may be placed in a salt bath of potassium nitrate and sodium nitrite. Residual amounts of both the releasing agent and the potassium and sodium salts may remain on the gasket and could result in contamination of the precipitation samples. In 1979 and 1980 concern about sample contamination from the leaching of calcium, magnesium and sodium from the gasket of the bucket lids was raised. Extensive testing was begun at the CAL to quantify and solve the problem. Begining in October 1981 the lids were pre-soaked for 24 hours in deionized water. This water was removed and a fresh supply used to soak the lids for an additional 24 hours. The lids were then washed (at first by hand and then in the dishwasher once it was available), shaken free of excess water, and placed in plastic bags and sealed. This routine soaking of the bucket lids for 48 hours was shown to effectively eliminate the problem. In an effort to further minimize the contact of precipitation samples with the gasket materials, in August 1982, the CAL affixed cautionary labels to all black shipping boxes requesting shipment and handling in an upright position.

To determine the contribution the container might make to the analyte concentrations, clean buckets and lids were randomly selected and used to determine container blanks. A predetermined volume of deionized water was poured into the test bucket, the lid pounded on, and the water left to equilibrate in the bucket. After 24 hours, this bucket leachate was poured into a DI water-washed 60 mL polyethylene (LPE) bottle and the concentration of analytes determined.

The first sets of blanks were obtained using 50 mL of DI water with the buckets remaining upright during the period of equilibration. For all of the bucket blanks, after the water was added and the lid securely hammered in place, the bucket was vigorously shaken to contact all surfaces of the bucket and lid before being left to equilibrate. In 1980, two additional blanks were added to explore the effect of larger volumes of DI water on the analyte concentrations. In addition to the bucket with a 50 mL portion of DI water, a second containing 150 mL and a third with 500 mL of DI water, were allowed to equilibrate overnight. One 60 mL aliquot was collected from each of these test buckets to provide the sample for analysis. Figures 1-24 in Appendix B are plots of the analyte masses found in these bucket blanks for 1979 through 1983.

For all volumes of all types of bucket blanks, the measured orthophosphate concentrations were at or below the method detection limit; therefore, plots of orthophosphate masses are not included. The concentrations of the measured analytes have been converted to micrograms per bucket in order to place the data for all three volumes on the same plot. Mass per bucket is calculated by multiplying the analyte concentration in units of micrograms per milliliter by the sample volume in milliliters. A legend defining the symbols being used is presented with each series of analyte plots. The dashed line near the bottom of each plot represents the minimal detectable mass for that analyte. This minimum value was determined by multiplying the MDL expressed as milligrams per liter by 50 mLs. For all three volumes, values measured as less than the method detection limit were plotted on this line. Table 1 in Appendix B lists the MDL mass for all of the parameters for which there are bucket blank plots.

It was hypothesized that the effect of increasing the volume of DI water used for the bucket leachates would be that of diluting the analyte concentrations. The figures for the data from 1980 and afterwards indicate that this was a correct assumption. It applies to both the upright and the inverted blanks.

The precipitation samples received and analyzed by the CAL arrive from all sections of the country. The time a sample spends in transit may vary from a few hours to several days. The upright bucket blanks did not adequately represent the container exposure a precipitation sample would have during transit since during transport the buckets would not always remain in an upright position. In an attempt to more truly mimic the actual conditions of 3 or 4 days of agitation while in transit from the field to the CAL, inverted bucket blanks were added in 1981. Figures 25 through 40 in Appendix B are plots of the analyte masses found in these inverted buckets for 1981 through 1983. These are again arranged chronologically and grouped by analyte. The same symbols for the three sample volume masses are used. The same three sample volumes were used, but the buckets were inverted for the period of equilibration. This provided maximum contact between the DI water and the rubber gasket, the suspected primary source of the contaminants. The figures of these inverted blanks indicate the potential for contamination that exists. They are, however, designed to demonstrate a worst case situation.

Table III-1 lists the number of bucket leachates analyzed for each year from 1978 to the present. Tables III-2 and III-3 present annual median masses again expressed as micrograms per bucket, from the start of the program to the present. The data document increased levels of analyte for 1983 and 1984. The source of this problem was traced to a clogged spray arm in the dishwasher. The city tap water used in the wash cycle, which contains high levels of calcium, magnesium, and sodium, was not being completely removed by the three DI water rinses. To correct the situation and prevent it from recurring, the entire wash cycle was converted in November 1984 to utilize deionized water only. The median values for 1985 indicate the problem was corrected and the bucket leachates now contain very limited amounts of all of the analytes of interest.

TABLE III-1 The Number of Bucket Blanks Analyzed Each Year from 1978 through 1985.

Year	Number of Blanks					
	Upright			Inverted		
	50mL	150mL	500mL	50mL	150mL	500mL
1979	14	----	----	----	----	----
1980	34	30	30	----	----	----
1981	28	28	28	6	6	6
1982	10	9	9	52	52	52
1983	10	10	10	45	45	45
1984	50	50	50	50	50	50
1985	47	47	47	44	44	44

TABLE III-2 **Upright Bucket Blanks - Median Concentrations Expressed as Micrograms/Bucket.**

Analyte	Year 1979	1980	1981	1982	1983	1984	1985
Calcium	<1.00	<1.00	8.63	2.77	2.33	7.10	0.58
Magnesium	<0.10	0.27	2.12	1.23	1.70	4.62	0.30
Sodium	<0.20	<0.20	4.87	1.98	6.27	9.58	0.47
Potassium	<0.20	<0.20	1.27	1.58	2.88	1.68	0.18
Sulfate	<5.0	<5.0	23.3	<5.0	<5.0	8.9	<1.5
Chloride	<2.5	<2.5	1.9	<1.0	3.9	4.3	<1.5
Nitrate-Nitrite	<1.0	<1.0	<1.0	<1.0	1.2	<1.0	<1.5
Ammonium	<1.0	<1.0	<1.0	<1.0	1.5	1.4	<1.0
Ortho-phosphate	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15

TABLE III-3 **Inverted Bucket Blanks - Median Concentrations Expressed as Micrograms/Bucket.**

Analyte	Year 1981	1982	1983	1984	1985
Calcium	5.57	8.92	11.02	16.83	1.95
Magnesium	6.91	2.48	4.13	9.17	1.38
Sodium	5.12	4.95	11.18	20.57	1.45
Potassium	0.65	1.27	2.10	3.20	0.43
Sulfate	8.3	5.5	6.0	24.2	3.2
Chloride	14.8	3.3	4.8	14.6	1.8
Nitrate-Nitrite	<1.0	1.3	1.3	1.5	<1.5
Ammonium	<1.0	1.2	1.8	1.3	<1.0
Ortho-phosphate	<0.15	<0.15	<0.15	<0.15	<0.15

B. FILTER LEACHATES

Before being used to filter precipitation samples, the 0.45 um Millipore filters are leached with a 200 mL aliquot of deionized water. The routine procedure consists of taking a new filter for each sample, leaching that filter, filtering the sample, then discarding the used filter. To ensure that the leaching procedure removes all analytes that are routinely measured in precipitation samples, analyses of filter leachates have been performed since 1979. This quality control check is performed by pouring a 50 mL portion of DI water through a leached filter and collecting the sample for analysis. These filter leachates are labeled the "A" sample.

In 1979, these samples were collected and analyzed each day precipitation samples were processed at the CAL. Table III-4 summarizes the data obtained from the analysis of these daily filter leachates. The data indicate that neither the filters nor the filtration procedure represented a significant source of sample contamination in 1979. These findings resulted in a change in the procedure used to collect the filter leachates.

TABLE III-4 Analyte Concentration Summary for Filter Leachate A for 1979.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L) 50th	Percentile (mg/L) 95th
Calcium	227	0.02	95.2	<0.02	<0.02
Magnesium	227	0.002	95.2	<0.002	<0.002
Sodium	227	0.004	58.6	<0.004	0.017
Potassium	227	0.004	76.2	<0.004	0.006
Ammonium	233	0.02	94.9	<0.02	<0.02
Sulfate	233	0.10	95.7	<0.10	<0.10
Nitrate-Nitrite	233	0.02	95.7	<0.02	<0.02
Chloride	233	0.05	93.1	<0.05	<0.05
Ortho-phosphate	233	0.003	65.7	<0.003	0.010

a. number of analyses

The frequency of filter leachate collection was reduced to once per week in 1980. By March of that year it was decided to make a further change in the procedure by collecting and analyzing a second 50 mL portion of DI water that had been poured through the same leached filter as had the "A" sample. This leachate is labeled the "B" sample. The new procedure provided additional information regarding the sample processing by indicating the possible contamination that may occur when more that one sample aliquot was collected. These data become important when reviewing the replicate sample analyses and analysis of those samples placed into archival storage. Tables III-5 and III-6 present the median concentration values found from the routine analyses of these A and B filter leachates for the period 1980-1983. More complete annual summaries of the analyses of the filter leachates can be found in Tables 2-9 in Appendix B. The data presented in these tables show the filters to be a negligible source of contamination. The routine weekly monitoring of these leachates continues as an intergral part of the CAL quality assurance program.

TABLE III-5 Median Analyte Concentration Found in Filter Leachate A for 1980 through 1983.

	Median Concentration (mg/L)			
Analyte/Year	**1980**	**1981**	**1982**	**1983**
Calcium	<0.02	<0.009	<0.009	<0.009
Magnesium	<0.002	<0.003	<0.003	<0.003
Sodium	<0.004	0.008	0.008	0.004
Potassium	<0.004	<0.003	<0.003	<0.003
Ammonium	<0.02	<0.02	<0.02	<0.02
Sulfate	<0.10	<0.10	<0.10	<0.10
Nitrate-Nitrite	<0.02	<0.02	<0.02	<0.02
Chloride	<0.05	<0.02	<0.02	<0.02
Orthophosphate	<0.003	<0.003	<0.003	<0.003
n[a]	65	35	41	49

[a] number of analyses

TABLE III-6 Median Analyte Concentration Found in Filter Leachate B for 1980 through 1983.

Analyte/Year	Median Concentration (mg/L) 1980	1981	1982	1983
Calcium	<0.02	<0.009	<0.009	<0.009
Magnesium	<0.002	<0.003	<0.003	<0.003
Sodium	<0.004	<0.003	<0.003	<0.003
Potassium	<0.004	<0.003	<0.003	<0.003
Ammonium	<0.02	<0.02	<0.02	<0.02
Sulfate	<0.10	<0.10	<0.10	<0.10
Nitrate-Nitrite	<0.02	<0.02	<0.02	<0.02
Chloride	<0.05	<0.02	<0.02	<0.02
Orthophosphate	<0.003	<0.003	<0.003	<0.003
n[a]	34	34	41	49

[a] number of analyses

C. DEIONIZED WATER

The final routine quality control check was on the quality of the deionized water used throughout the laboratory. Although the purity of the water was always monitored by daily checks of specific conductance by an in-line conductivity meter, the complete analysis of a DI water sample did not begin until 1980, and was at first was done somewhat irregularly. By 1981 weekly samples were regularly being taken from the sample processing laboratory for a complete analysis.

During the six years under discussion three different types of deionizing systems were used by the CAL. The first system was utilized by the entire Water Survey and was supplied by the Illinois Water Treatment (IWT) Company. It consisted of a mixed bed ion exchange column with automatic shut down when the conductivity of the DI water being produced exceeded 0.5 uS/cm. The water produced by the IWT system was then passed through a two cartridge Barnstead Nanopure mixed bed ion exchange system before being used. In June of 1981 the sample processing lab moved to another section of the Water Survey and a separate deionizing system was installed. The sample processing laboratory is that part of the CAL where the network samples are filtered and collected for analysis. The pH and specific conductance measurements are made by the processing laboratory staff. The newly installed system employed reverse osmosis (RO) to convert the city tap water to DI water with a conductivity of <1 uS/cm. Because of the high pH of the tap water (pH 8.5) an acid feed line was needed to inject dilute sulfuric acid into the tap water before it was sent through the RO system. This was necessary because the high pH degraded the RO membrane. In April 1983 this early membrane was replaced by a thin film composite type which was unaffected by high pH and the need for the acid feed step was eliminated. This RO system produced 40 L of DI water per hour and remained in use in the processing laboratory until the CAL moved to new facilities in November 1985. The remaining analytical staff of the CAL continued to use DI water produced by the IWT system in conjunction with Barnstead wall-mounted Nanopure systems for sample dilutions and standards and reference sample preparations. The water system available for their use also changed with the move in November 1985.

Table III-7 lists the median analyte concentrations found in the deionized water used by the CAL. Tables 10-13 in Appendix B contain annual summaries of the data obtained from the analyses of this DI water. As with the filters, the laboratory deionized water has proven to be a negligible source of contamination. Analysis of deionized water used in the sample processing laboratory as well as a DI water samples taken from one of the analytical labs at the CAL continues as part of the routine quality assessment program.

TABLE III-7 Median Analyte Concentration Values for Deionized Water Blank for 1980-1983.

Analyte/Year	Median Concentration Value (mg/L) 1980	1981	1982	1983
Calcium	<0.02	<0.009	<0.009	<0.009
Magnesium	<0.002	<0.003	<0.003	<0.003
Sodium	<0.004	<0.003	<0.003	<0.003
Potassium	<0.004	<0.003	<0.003	<0.003
Ammonium	<0.02	<0.02	<0.02	<0.02
Sulfate	<0.10	<0.10	<0.10	<0.10
Nitrate-Nitrite	<0.02	<0.02	<0.02	<0.02
Chloride	<0.05	<0.02	<0.02	<0.02
Orthophosphate	<0.003	<0.003	<0.003	<0.003
n[a]	20	33	39	48

[a] number of analyses

IV. LABORATORY BIAS AND PRECISION

An essential part of every quality assessment program is the determination of the accuracy of the measurements being made by the laboratory. One way of making this determination is to examine the bias and precision of data obtained from replicate analyses of Quality Control Check (QCC) samples. The QCC samples used by the CAL for these calculations are either internally formulated solutions or dilutions of mineral and nutrient concentrates provided by the United States Environmental Protection Agency, EMSL-Cincinnati, Ohio. Additional information regarding laboratory precision can be obtained through the analysis of replicate samples, i.e. the analysis of two aliquots of the same sample. Section IV contains descriptions of both the QCC and replicate samples used by the CAL to assess laboratory performance. Summary tables and plots of the analyses of these samples are provided in this report accompanied by a discussion of what the data indicate about the performance of the Central Analytical Laboratory.

A. QUALITY CONTROL CHECK SAMPLE DATA

The types of internal quality control samples have not changed for the period being discussed. However, the sample concentrations for the quality control check samples used to determine analytical bias and precision have changed for two reasons. The first is a reformulation of the concentrates by the USEPA. This typically occurs once every year. The second reason is an attempt by the laboratory to dilute the USEPA concentrates so the resulting analyte concentrations approximate the twenty-fifth and seventy-fifth percentile concentrations measured in the samples from the sites in the NADP/NTN network. These values vary some from year to year. Table IV-1 lists the twenty-fifth percentile concentration values for each parameter measured in the precipitation samples collected in the NADP/NTN network from 1978 through 1983. Table IV-2 presents the seventy-fifth percentile concentration values for the same period. More comprehensive annual percentile concentration summaries can be found in Tables 1 through 6 in Appendix C.

A minimum volume of 35 mL of sample is necessary for a complete analysis of all eleven precipitation parameters. Samples containing less than 35 mL are diluted as indicated in Figures II-1 and II-2. Because of this processing procedure, only samples which were greater than 35 mL in volume have been included in the preparation of the percentile concentration tables.

A cursory examination of Tables IV-1 and IV-2 reveals changes in analyte percentile concentration values during the 1978-1983 period. These changes are primarily due to the geographical distribution of monitoring sites as the program grew in size. In the early stages of the program, most of the network sites were located in the northeastern and central regions of the country. Precipitation from these areas is generally characterized by lower pH values and higher sulfate and nitrate concentrations than the rain from sites in the west and the high plains. The network expansion from 1979 through 1981 added new

TABLE IV-1 Twenty-fifth Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation for 1978-1983.

	Percentile Concentration Values (mg/L)					
Parameter/Year	1978	1979	1980	1981	1982	1983
Ca	0.07	0.09	0.09	0.10	0.07	0.07
Mg	0.019	0.022	0.022	0.033	0.023	0.021
K	0.020	0.015	0.015	0.016	0.015	0.016
Na	0.090	0.100	0.054	0.058	0.043	0.048
NH_4	0.04	0.07	0.07	0.08	0.08	0.06
NO_3	0.60	0.76	0.72	0.60	0.58	0.51
Cl	0.13	0.10	0.18	0.10	0.09	0.10
SO_4	1.30	1.45	1.13	1.08	0.85	0.78
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
pH (units)	4.19	4.26	4.25	4.29	4.35	4.42
Specific Conductance (uS/cm)	11.7	12.2	12.4	11.9	9.3	8.3
n[a]	239	1254	3030	3370	3590	4308

a. number of samples

TABLE IV-2 Seventy-fifth Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation for 1978-1983.

	Percentile Concentration Values (mg/L)					
Parameter/Year	1978	1979	1980	1981	1982	1983
Ca	0.32	0.42	0.43	0.48	0.35	0.36
Mg	0.081	0.086	0.093	0.137	0.091	0.082
K	0.060	0.060	0.065	0.066	0.052	0.060
Na	0.565	0.620	0.351	0.313	0.216	0.238
NH_4	0.38	0.50	0.50	0.44	0.39	0.40
NO_3	2.25	2.49	2.63	2.15	1.94	1.86
Cl	0.51	0.40	0.48	0.47	0.38	0.36
SO_4	3.96	4.30	3.74	3.82	2.99	2.59
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
pH (units)	4.93	5.07	5.36	5.46	5.33	5.37
Specific Conductance (uS/cm)	31.2	34.3	35.7	35.1	29.8	26.0
n[a]	239	1254	3030	3370	3590	4308

a. number of samples

sites along both eastern and western coasts, as well as, in the south and midwest. The increased levels of both sodium and chloride in the network samples during this period was principally due to the inclusion of these new coastal sites. Similarly, midwestern rainfall is generally characterized by higher calcium, magnesium, and ammonium concentrations and increased levels of these ions is also seen during this period. By the end of 1981, the area east of the Mississippi River was well represented in the network and subsequent expansion has been predominated by the addition of sites from the western and great plains regions of the country. The addition of these western sites has resulted in the general decline in the analyte concentrations found in the network as a whole during 1982 and continuing into 1983.

As the network expanded, the number of precipitation samples being collected and analyzed increased. This resulted in an increase in the number of analyses of quality control samples as well. One example of this increase is that in 1980 a total of 275 QCS analyses were performed for calcium. By 1983 that number had grown to 934. The program grew in quantity of quality assessment data being produced but did not change in the types of samples being analyzed to produce these data. This section continues with a description of the quality control solutions used by the laboratory, presents summary tables of the data that resulted from their analysis and provides an explanation of what these data imply about the performance of the CAL.

Solutions Used

In 1979 and 1980 in-house formulations of sulfuric acid and nitric acid were used to monitor the pH measurements. Similar solutions were utilized as quality control samples for the specific conductance. The frequency of measurement of these quality control samples was irregular until 1981. By 1981, samples with a pH and specific conductance more representative of the levels found in precipitation were formulated and a systematic program of measurements initiated.

Since 1981, a dilute nitric acid solution (5.01×10^{-5}N HNO_3) prepared by the CAL has been used to monitor pH and specific conductance measurements. The solution preparation is verified by measuring the pH and specific conductance and by analyzing it colorimetrically for NO_3 and titrimetrically for acidity. The information obtained from these determinations is used to derive the calculated pH and specific conductance values. The solution must have a calculated pH of 4.30 ± 0.03 and a calculated specific conductance of 21.8 ± 2 uS/cm to be considered suitable for use in both the laboratory and the field. The information available on Tables 1 through 6 in Appendix C indicates that the pH of this solution falls near the 25th percentile concentration level and the specific conductance near the 50th percentile for all of the years being discussed.

Again since 1981, a dilute potassium chloride solution (5.0×10^{-4}N KCl) formulated and prepared at the CAL, has been used to both calibrate the conductivity bridge and cell and to monitor pH measurements at a second concentration level. The accuracy of this preparation is determined by measurement of pH and specific conductance, the colorimetric determination of the chloride concentration and the analysis of the potassium concentration by flame atomic absorption spectroscopy. These analytical data are used to calculate the pH and specific conductance of the preparation. Although this is a stable solution, its calculated pH of 5.63 falls within the range of pH where the effects of atmospheric carbon dioxide fluctuations can be significant. For the aforementioned reason the range of acceptable readings for pH is 5.63 ± 0.3 pH units. The acceptable range for the calculated specific conductance is 74.8 ± 2 uS/cm.

The bias and precision of the remaining analytical parameters were monitored by performing replicate analyses of dilute QCC solutions prepared from USEPA mineral and nutrient concentrates. The mineral sample was used to prepare QCC solutions for calcium, magnesium, sodium, potassium, sulfate, and chloride. The QCC solutions for nitrate-nitrite, ammonium, and orthophosphate were made by diluting the USEPA nutrient concentrates. Two QCC solutions were prepared for each analyte. One solution approximated the 25th percentile concentration found for the specified analyte and the other, the 75th. These percentile concentration values were derived from the network history of the preceding year and can be found in Tables IV-1 and IV-2.

Analytical Bias and Precision Tables

The formulas used to calculate the bias and precision data can be found in the Glossary (Appendix A). All data presented for the measurement of pH required the conversion of the measurements from pH units to hydrogen ion content as microequivalents per liter before these formulas could be employed. Table 1 in Appendix D lists several pH values and their corresponding hydrogen ion content. Table 2 summarizes the pH data and presents the mean and standard deviation values in both pH units and microequivalents per liter. The percent bias and percent relative standard deviation (RSD) values are calculated using hydrogen ion concentration only.

Tables 2 through 12 in Appendix D were prepared from the data obtained from replicate analysis of QCC samples. For all parameters except pH and specific conductance, at least one QCC sample was analyzed with each group of twelve precipitation samples. For pH and specific conductance measurements, the frequency was approximately one QCC sample measured for every twenty precipitation samples. The annual summaries of bias and precision for each parameter (Tables 2-12) found in Appendix D were produced using the results obtained from the statistical analysis of this QCC sample data. These tables provide one means of assessing the quality of the analytical data produced at the CAL by presenting summaries of the analyses of solutions whose analyte concentrations were known to each analyst.

As mentioned before, the primary source of the QCC samples being analyzed was the USEPA. With each of the mineral and nutrient concentrates that it supplies, the USEPA provides directions for sample preparation plus a data sheet containing the expected concentrations that should result after dilution. Beginning with the USEPA reference samples the CAL was using in 1981, the data sheet that accompanied the sample concentrates listed an expected concentration, a mean concentration with a standard deviation, and a confidence interval for the concentrations that should result after dilution. These mean and standard deviation values were obtained from statistical analysis of the data received from USEPA sponsored round robin performance studies (2). Summaries of the data obtained from these performance studies can be obtained from the USEPA, EMSL-Cincinnati, Ohio. Beginning with the data from 1981, the USEPA mean is listed in the theoretical concentration column and is used to calculate the analytical bias values listed in Tables 4-12 in Appendix D.

The last column of the tables indicates whether the bias that has been calculated from the CAL data is or is not statistically significant. To determine this, a t-test was used to compare the mean values measured at the CAL to those provided by the USEPA on its data sheets. For the years prior to 1981 when the mean and standard deviation values were not available from the USEPA, the theoretical value was used for the analytical bias calculations and an estimated standard deviation consistent with those found in the succeeding years was used to test for the statistical significance of that bias.

Discussion of Results

A review of the annual data summaries of bias and precision indicates few problems with analytical bias. It was not possible to calculate the significance of the bias for pH and specific conductance for 1979 and 1980 as the samples used were in-house formulations and the preparations were not verified through analyses of the ions in solution. During this period, the CAL staff was experimenting with what formulations might be appropriate for use in the sample processing lab and were not as concerned with the accuracy of the preparation as with the stability of the samples. The bias in the pH measurements reported in 1979 may in large part be due to this preparation inaccuracy. By 1980 the QCC samples for pH and specific conductance were carefully prepared and the bias reported more accurately reflects what might have existed at that time. Beginning in 1981, when sample preparation verification became routine, the uncertainty in the sample preparation was used to perform the same statistical analysis for the significance of the bias as was used for the other analytical parameters. For all pH and specific conductance measurements of the pH 4.30 QCC sample (specific conductance of 21.8 uS/cm) for 1981-1983, the bias found was not statistically significant. The allowable variation in the preparation of the dilute nitric acid solution (pH 4.30 QCC sample) was 0.10 pH units and that for the dilute potassium chloride conductivity standard (pH 5.63 QCC sample), 0.30 pH units. These large uncertainties allow for a considerable bias in sample measurements before that bias becomes statistically significant, particularly for the pH 5.63 sample. The bias in 1982 and 1983 for the pH 5.63 sample proved to be statistically significant. As noted earlier, at pH levels of greater then 5.0 the effect of atmospheric carbon dioxide on sample pH becomes important. Also at this pH level, the hydrogen ion concentration is very low and acceptable variations in pH values result in large percent bias. The bias listed in Table 2 of Appendix D for the pH 5.63 sample are at first startling, but the preceeding discussion should have shown that the variation allowable in the sample preparation was the primary reason for the large discrepancies. The standard deviation for this sample provides a better assessment of the laboratory peformance and that improved or remained consistent, particularly for the last three years under discussion.

Although the results of the t-test sometimes show the deviation of the CAL mean from the theoretical value or USEPA mean to be statistically significant, the actual amount of the difference in terms of analyte concentration is small. When the percent bias is large, as with the 13.4% negative bias for the lowest concentration reference sample used for calcium in 1980, it is primarily due to the small amount of analyte present in the solution. As analyte concentrations decrease, the degree of difficulty in obtaining accurate dilutions and analyses increases. This fact is emphasized by the increased variability in precision that accompanied this large bias. Of more importance, particularly when reviewing the data summaries for the metal cations, is the fact that with the increased experience of the analyst comes improvement in both the percent bias and the precision at even the lowest concentration levels.

When considering the data summaries for the analytes ammonium, nitrate-nitrite, and orthophosphate, the instability of these species must be remembered. The percent bias and RSD for nitrate-nitrite are quite acceptable at all levels. The ammonium data are also satisfactory. The orthophosphate data, however, reflect the effects of sample instability. Although not apparent from the data summaries presented in Table 12, the negative percent bias present in 1981, 1982, and 1983 was primarily due to QCC sample decomposition. Review of all of the data for each year showed a consistent downward trend in the orthophosphate concentration of the QCC sample over a relatively short time (3-4 days). This information led to a procedural change that required both the standards and the QCC samples to be prepared more frequently. The new procedure resulted in improved bias and precision data for orthophosphate in the subsequent years.

Finally, the data summaries for chloride exhibit the expected improvement in measurement accuracy as analyst's experience with both the method and instrumentation increased. The generally poor precision of the sulfate data from 1982 and 1983 reflects the importance of the analyst's skills to the accuracy of the measurements in yet another manner. The staff summary in Table II-2 shows that during this period there were three different analysts performing the sulfate determinations. The Methyl Thymol Blue method used for these determinations requires a rigorous routine maintenance program to ensure precise results. Analyst turnover during the 1982-1983 time period likely resulted in the degradation of precision due to inexperience.

B. REPLICATE SAMPLE DATA

From the inception of the program, replicate samples were analyzed and the data used to evaluate laboratory precision. These splits were made in the sample processing section of the lab. Three 60 mL aliquots were collected after filtration from four percent of the precipitation samples arriving at the CAL. The same laboratory sample number was given to each of the samples with the first aliquot taken being designated A; the second, B; and the third refrigerated for storage in the sample archives. Samples A and B were subsequently placed side by side on a sample tray and submitted for analysis. Typically, the analysis of the B sample immediately followed analysis of the A sample. The fact that these were two aliquots of the same sample was known to all of the analysts.

The next section of this report discusses the plots of the data derived from these replicate analyses. The plots are presented as Figures 1-50 in Appendix E. They are arranged by parameter with each figure representing one year's analyses. Because of the limited data from 1978, the analytical values for the replicate analyses from that year have been combined with those from 1979. Interpretation of the data and a summary statement about laboratory precision from 1978 through 1983 are included.

Range Selection

The figures in Appendix E are plots of the concentration differences between replicate samples A and B in mg/L versus the average concentration of A and B in mg/L. The differences are always calculated using the formula [analyte concentration of A minus analyte concentration of B]. The average is [analyte concentration of A plus analyte con- centration of B] divided by two. To facilitate the usefulness of the plots, the yearly assessments for each ion have been split into two sections. A median concentration for the six-year period under discussion was determined for each analyte. The first plot in each figure includes the range from 0 mg/L to the median concentration of the analyte of interest. The second plots of the figures begin with the median concentration value and continue to the ninety-fifth percentile concentration of that analyte found in the replicate samples analyzed during the entire period. Table IV-3 lists the median or fiftieth percentile and the ninety-fifth percentile concentrations for each analyte for the period 1978-1983.

Tables and Plots

Figures 1-50 in Appendix E are plots of the differences found at the CAL between two aliquots of the same precipitation sample analyzed in succession. The plots are grouped by analyte and each figure contains both low and high concentration plots for a single year. Plots of the difference between A and B are presented for all analytes except orthophosphate. The number of precipitation samples containing orthophosphate is small and the number of replicate samples containing differences in the orthophosphate concentrations, still smaller. Table IV-4 lists the percentage of splits which contained no measurable orthophosphate from 1978 through 1983. The difference between the orthophosphate concentration measured in samples A and B of the four to eight percent of the splits that contained the analyte was 0.000 mg/L for all but 1% of the samples. Plots of these differences were deemed unnecessary.

TABLE IV-3 Fiftieth and Ninety-fifth Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation Samples Selected for Replicate Analyses for 1978-1983.

Parameter	Percentile Concentration Values (mg/L) Fiftieth	 Ninety-fifth
Calcium	0.100	0.500
Magnesium	0.025	0.125
Sodium	0.100	0.500
Potassium	0.025	0.125
Ammonium	0.20	1.00
Sulfate	1.50	7.50
Nitrate-Nitrite	1.00	5.00
Chloride	0.30	1.50
pH (units)	4.50	6.50
Specific Conductance (uS/cm)	15.0	75.0

TABLE IV-4 Percentage of Replicates in which the Concentration of Orthophosphate Is Less Than the Method Detection Limit.

Year	Percent
1978-1979	92.6
1980	96.0
1981	93.1
1982	94.8
1983	93.7

Table IV-5 lists the mean differences for each analyte for the period being discussed. Tables 1-5 in Appendix E present complete annual statistical summaries of the differences plotted in Figures 1-50. Again, because the number of splits taken in 1978 and 1979 was small, the data from these two years have been combined in both the plots and the statistical summaries.

Discussion of Results

The data presented in both the figures and the tables indicate that the precision at the CAL for splits analyzed in sucession was always very good. The plots in particular show a continuous improvement in analyst precision from the start of the program through 1983. The differences are almost always within three times the MDL for each analyte and in most cases are within two times the MDL. Precision of this quality is what should be expected for these types of analyses where the analyses are performed in succession. The need for a different source of information to be used in the assessment of analytical precision was apparent. Splits that were blind to the analysts and analyzed at different times were added to the quality assurance program in 1984 to provide this additional imformation. The data that resulted from the analysis of these blind splits will appear in the Quality Assurance Report for the years 1984-1985.

TABLE IV-5 Mean Differences for Replicate Analyses of Precipitation Samples for 1978-1983.

	Mean Difference (mg/L)				
Parameter/Year	1978-1979	1980	1981	1982	1983
Calcium	0.001	0.000	0.000	-0.001	0.001
Magnesium	0.000	0.000	0.000	0.000	0.000
Sodium	-0.001	0.000	-0.001	0.000	0.001
Potassium	0.000	0.000	0.000	0.000	0.000
Ammonium	-0.01	0.00	0.00	0.00	0.01
Sulfate	0.00	0.00	0.00	-0.01	-0.01
Nitrate-Nitrite	0.00	0.00	0.00	0.01	0.00
Chloride	0.00	0.00	0.00	0.00	0.00
pH (units)	0.01	0.01	-0.01	0.00	-0.01
Specific Conductance (uS/cm)	-0.2	-0.1	0.0	0.0	0.0
n[a]	54	125	175	212	255

[a] number of replicate pairs

V. REANALYSIS PROCEDURES

Once the analyte concentrations are determined in a precipitation sample, the information is entered into the CAL data base. The analyte concentrations are converted from milligrams per liter to microequivalents per liter and an ion balance calculation is made for each sample. The information resulting from this calculation is used to select approximately 8 percent of the samples for reanalysis.

An ion balance may be calculated using one of several different methods. Figure V-1 presents four commonly employed methods and demonstrates how the results obtained from each can be compared to those derived from the other methods. These methods may vary from a simple ion ratio as utilized by the NADP/NTN in the annual data summaries (3) to the more complex calculations recommended by the USEPA (4). Although similar to the calculation method employed at the CAL, the formula recommended by the American Society for Testing and Materials (ASTM) (5) is:

$$\text{Percentage Error} = \frac{\text{Cations} - \text{Anions}}{\text{Cations} + \text{Anions}} \times 100$$

It is important to know which method a laboratory employs, not only for purposes of data comparisons, but also for data interpretation, particularly when this information will be used to evaluate laboratory performance.

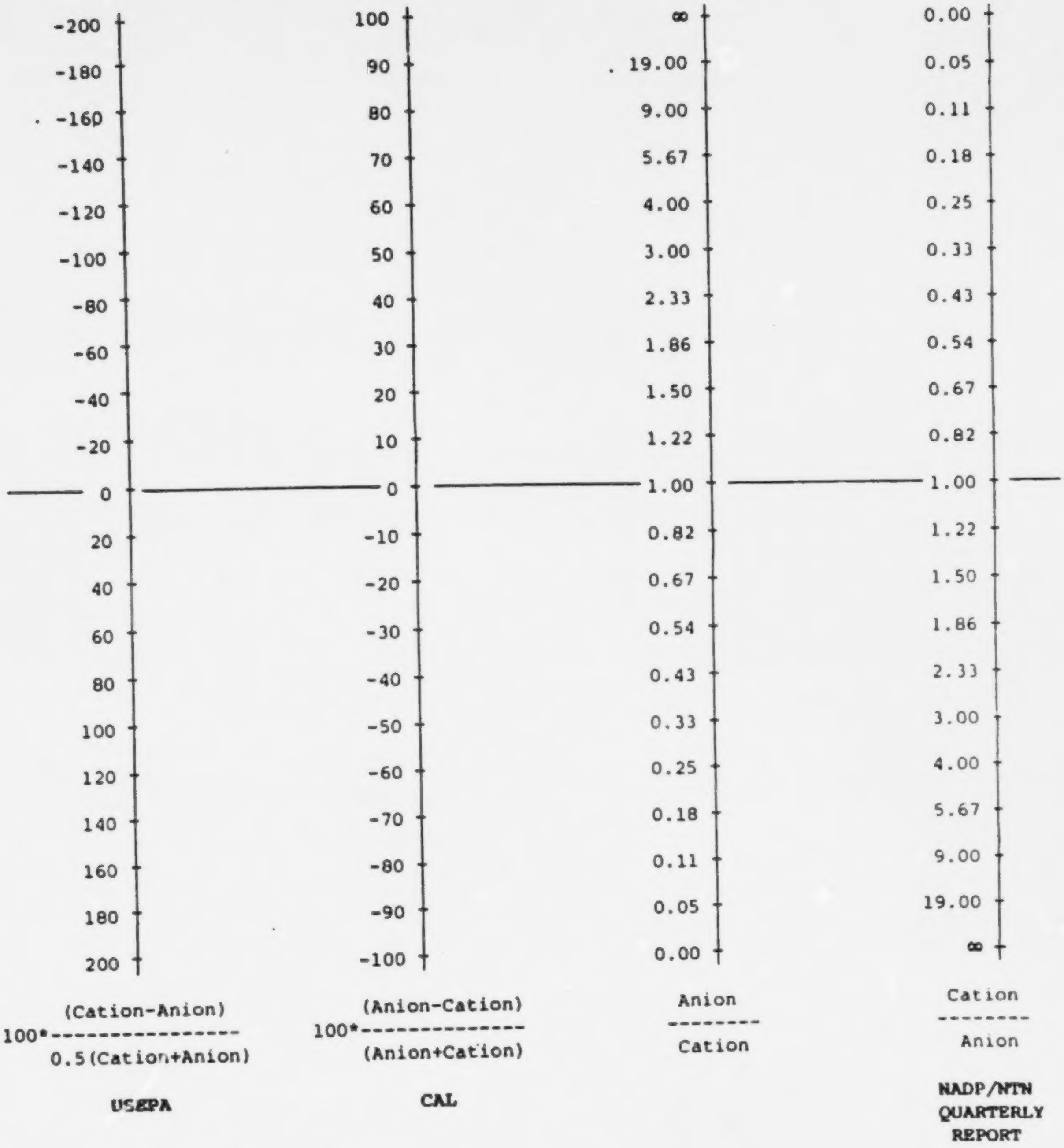
The calculation method used by the CAL is more completely described in Figure V-2. The factors used to convert the measured analyte concentrations from milligrams per liter to microequivalents per liter are listed in Table V-1. These were taken from Standard Methods for the Examination of Water and Wastewater(6).

TABLE V-1 The Factors Used to Convert Analyte Concentrations from Milligrams per Liter to Microequivalents per Liter.[a]

Analyte	ueq/L = mg/L x
Calcium	49.90
Magnesium	82.26
Sodium	43.50
Potassium	25.57
Ammonium	55.44
Sulfate	20.83
Nitrate	16.13
Chloride	28.21
Orthophosphate	31.59

a. Factors taken from Standard Methods for the Examination of Water and Wastewater (6).

COMPARISON OF
ION BALANCE CALCULATION METHODS


-200
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
(Cation-Anion)
100*----------------
0.5(Cation+Anion)
USEPA
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
(Anion-Cation)
100*--------------
(Anion+Cation)
CAL
∞
19.00
9.00
5.67
4.00
3.00
2.33
1.86
1.50
1.22
1.00
0.82
0.67
0.54
0.43
0.33
0.25
0.18
0.11
0.05
0.00
Anion

Cation
0.00
0.05
0.11
0.18
0.25
0.33
0.43
0.54
0.67
0.82
1.00
1.22
1.50
1.86
2.33
3.00
4.00
5.67
9.00
19.00
∞
Cation

Anion
NADP/NTN
QUARTERLY
REPORT

FIGURE V-1. A comparison of four methods that can be used to calculate an ion balance.

NADP/NTN Ion Balance
Calculation Method

$$\text{Ion \% Difference} = \frac{(\text{Anions} - \text{Cations})}{(\text{Anions} + \text{Cations})} \times 100$$

$$\text{Anion}^{*} = (SO_4^{-2}) + (NO_3^{-}) + (Cl^{-}) + (PO_4^{-3}) + (OH^{-}) + (HCO_3^{-})$$

$$\text{Cation}^{*} = (Ca^{+2}) + (Mg^{+2}) + (Na^{+}) + (K^{+}) + (NH_4^{+}) + (H^{+})$$

* Concentrations are expressed as microequivalents/liter

FIGURE V-2. The formula used by the CAL to calculate an ion balance.

It should be noted that the CAL includes bicarbonate ion concentration when calculating the anion sum for each sample. This is a calculated value that is based on the assumption that the sample is in equilibrium with atmospheric carbon dioxide. The final formula used to derive this calculated HCO_3^- concentration is:

$$(HCO_3^{-}) = \frac{K_1 \; K_H \; P_{CO_2}}{10^{-pH}} = \frac{5.11 \times 10^{-12}}{10^{-pH}}$$

where, K_1 = 4.46×10^{-7} moles per liter
K_H = 0.0342 moles per liter - atmosphere
P_{CO_2} = 335×10^{-6} atmospheres.

The bicarbonate concentration that is found by using the above formula is expressed as moles per liter. It is converted to microequivalents per liter by multiplying the calculated concentration by 10^6. A calculated HCO_3^- concentration is not necessarily part of the ion balance calculations used by other laboratories. Therefore, I stress again the importance of knowing the exact procedures utilized by each laboratory in its calculation of an ion balance, before attempting to compare laboratory performance by using ion balance as the criteria.

Ion balance calculations are a valuable component of the CAL quality assurance program. A large imbalance can be indicative of an error in the analysis. It may also be an indication that additional ionic species are present in the sample and further analyses are necessary to completely characterize the sample. By selecting a maximum allowable imbalance and reanalyzing all samples with an imbalance greater than this maximum, an imbalance that resulted from analytical error can be found and corrected.

In this section, the criteria used to select samples for reanalysis are presented. A discussion of the information that can be derived from these reanalysis procedures and their effect on the network data are also included.

A. Ion Balance Criteria

In 1978 and 1979, when the criteria for reanalysis were being formulated, very little information about the network was available. Initially, all samples with an ion imbalance of ± 15% or greater were selected for reanalysis. By early 1979, computer programs had been developed to generate plots that related measured pH values to the calculated ion percent difference (IPD) values generated by the ion balance calculation. Using the information provided by these plots and other information about analyte concentration changes that had resulted from the reanalyses of samples selected by the 15% criterion, the CAL director determined that more specific criteria based both on pH and IPD would be more appropriate. In October 1979, the criteria became:

when the CAL measured pH was ≤ 4.7,
reanalyze if the IPD was $> \pm 13\%$;

when the CAL measured pH was > 4.7,
reanalyze if the IPD was
a. greater than $[(-10.0 \times \text{pH}) + 61.0]$, or
b. less than $[(-10.0 \times \text{pH}) + 35.0]$.

These criteria were used throughout 1980 and most of 1981 to select approximately 8% of the total number of samples analyzed by the CAL to be reanalyzed.

During 1981, the nature of the network began to change as it expanded farther into the west. While the number of data changes that resulted after samples were reanalyzed remained the same, the number of samples being selected for reanalysis continued to increase with this network expansion. This occurred because many of the precipitation samples from the western sites met the second criterion for reanalysis selection. This also resulted in a progressively regionalized sample set being selected for reanalysis. The obvious need for different selection criteria prompted another analysis of the data changes made as the result of sample reanalysis. A closer look was taken at the types of samples that were collected and analyzed from the different regions within the network. In October 1981 a new set of criteria had been developed and the necessary changes made in the computer program.

The computer program that calculates an ion balance for each sample determines the ion sum or total ionic strength of the sample. The analyte concentrations have already been converted to microequivalents per liter as part of the ion balance calculation. To obtain the ion sum (IS) the total anion concentration expressed in microequivalents is added to the total cation concentration, also in microequivalents. Both the ion sum and the ion percent difference that result from the ion balance calculation were used in the new criteria to determine which samples should be reanalyzed. The ion balance criteria for reanalysis selection then became:

when IS < 50 ueq/L, reanalyze if IPD $> \pm$ 60%;

when 50 $\leq$ IS $\leq$ 100 ueq/L, reanalyze if IPD $> \pm$ 30%;

and, when IS $\geq$ 100 ueq/L, reanalyze if IPD $> \pm$ 15%

where IS = Ion Sum = (Anion + Cation) ueq/L,

$$\text{and, IPD = Ion Percent Difference} = \frac{(\text{Anion} - \text{Cation})}{(\text{Anion} + \text{Cation})} \times 100$$

The goal was to select 5-6% of the samples analyzed at the CAL for reanalysis. Time has proven this to be an adequate set of criteria to reach the desired goal and it has remained unchanged since its formulation in 1981.

B. Specific Conductance Criteria

Another part of the ion balance program uses the measured concentration of analytes to calculate a theoretical conductance for the sample. The formula used is:

$$\begin{aligned}\text{Calculated Conductance} = [&(H^+)(350) + (HCO_3^-)(43.6) + \\ &(Ca^{+2})(52.0) + (Cl^-)(75.9) + (Mg^{+2})(46.6) + \\ &(K^+)(72.0) + (Na^+)(48.9) + (NO_3^-)(71.0) + \\ &(SO_4^{-2})(73.9) + (NH_4^+)(72.5)] \div 1000\end{aligned}$$

where ion concentrations are in microequivalents per liter.

The conductance factors used in this calculation for hydrogen ion and ammonium can be obtained from the CRC Handbook of Chemistry and Physics(7). The remaining factors can be found in Standard Methods for the Examination of Water and Wastewater(6).

The calculated conductance is compared to the measured conductance and a conductance percent difference found. This comparison uses the following equation:

Conductance Percent Difference = CPD =

$$\frac{(\text{Calculated Conductance} - \text{Measured Conductance})}{\text{Measured Conductance}} \times 100$$

Once the CPD has been calculated, it can be used as another means of selecting samples for reanalysis. It was not until 1981 that suitable criteria were developed to utilize this CPD information. As with the ion percent difference, a large CPD may indicate a measurement error in one or more of the analytes. Percentile values for measured specific conductance from 1978-1981 were used to formulate a set of CPD criteria that was added to the ion balance program in October 1981. The CPD criteria are:

when conductance measured $\leq$ 10 uS/cm,
reanalyze if CPD > ± 65%;

when 10 uS/cm < conductance measured $\leq$ 30 uS/cm,
reanalyze if CPD > ± 45%;

when 30 uS/cm < conductance measured $\leq$ 50 uS/cm,
reanalyze if CPD > ± 30%;

and when conductance measured > 50 uS/cm,
reanalyze if CPD > ± 20%.

The percent of samples that meet these criteria is generally less than 2% and most often they have already been flagged because of an ion imbalance. It still provides another means of detecting large analytical errors and is a useful calculation to perform.

C. Histograms

Figures V-3 and V-4 are histograms of the ion percent difference values and the conductance percent difference values for the samples from the NADP/NTN network for the year 1983. The histograms for 1978 through 1982 can be found in Appendix F. With each histogram, a median, a mean, and a standard deviation are noted.

Although only samples with volumes greater than 35 mL are included in these graphs, they are still representative of the overall increase in the number of network samples during the period 1978 through 1983. Sampling did not begin until July 1978 and the histograms for that year represent only samples collected in the fall and winter from sites in the eastern and central regions of the United States. The increases in the numbers of samples analyzed in the succeeding years are the result of network expansion from the original 14 eastern and midwestern sites to aproximately 130 sites throughout the country by the end of 1983.

The IPD histograms for all six years depict a very similar pattern, as do the six CPD histograms. The IPD histograms approximate a normally distributed curve centering around the 0% difference point. This is what one would expect if the sample analysis includes the major anions and cations in precipitation. The eleven parameters selected for analysis at the CAL appear to adequately characterize the precipitation samples collected within the NADP/NTN network. Again, a normal distribution around the 0% difference point would be expected for the CPD histograms. It does not, however, occur. These plots have a negative skew. The calculated conductance is typically less than the measured conductance. This suggests either a measurement or a calculation problem. The accuracy of the measurement has been checked

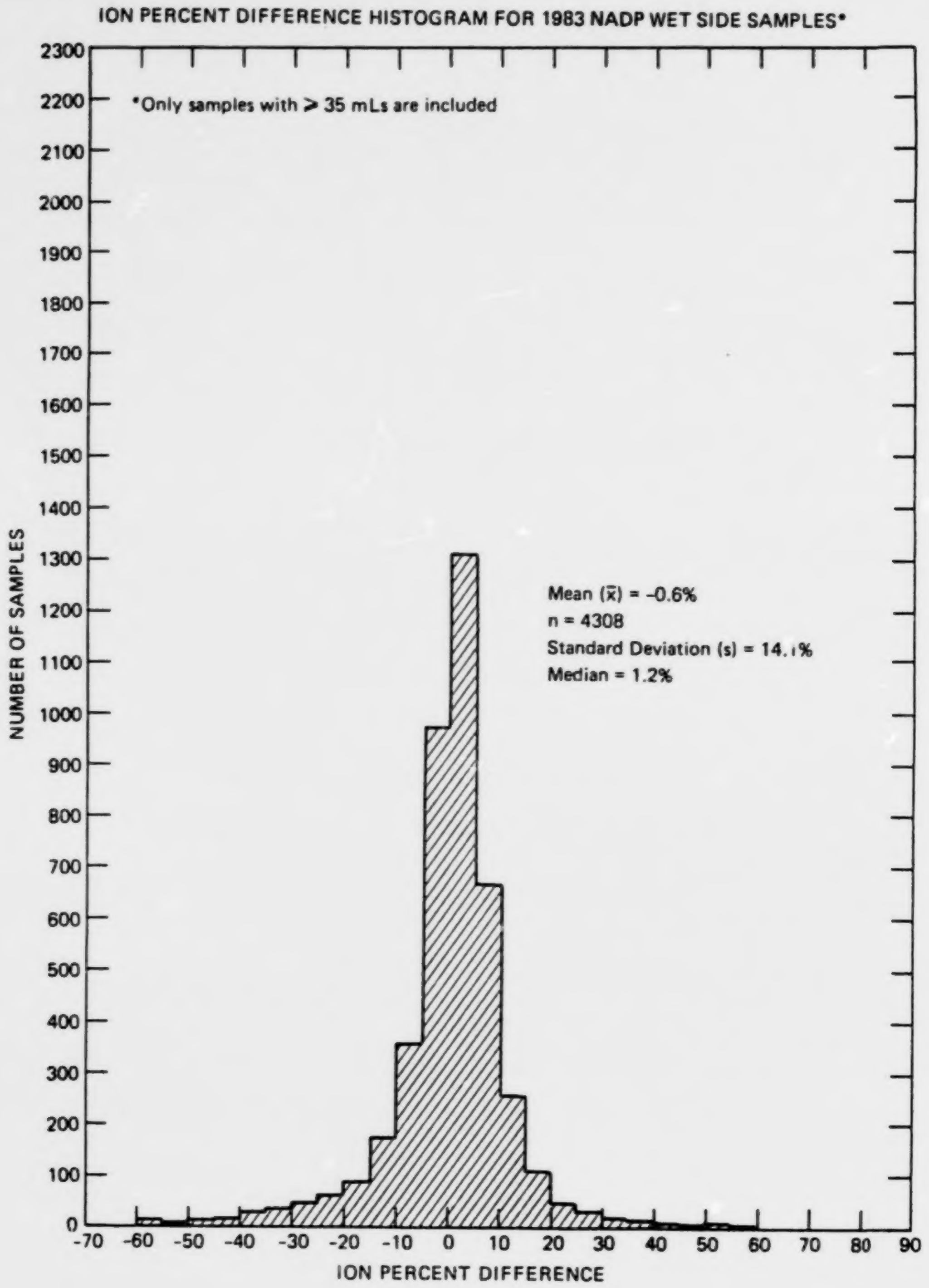


FIGURE V-3. Ion percent difference histogram for NADP/NTN wet side samples in 1983.

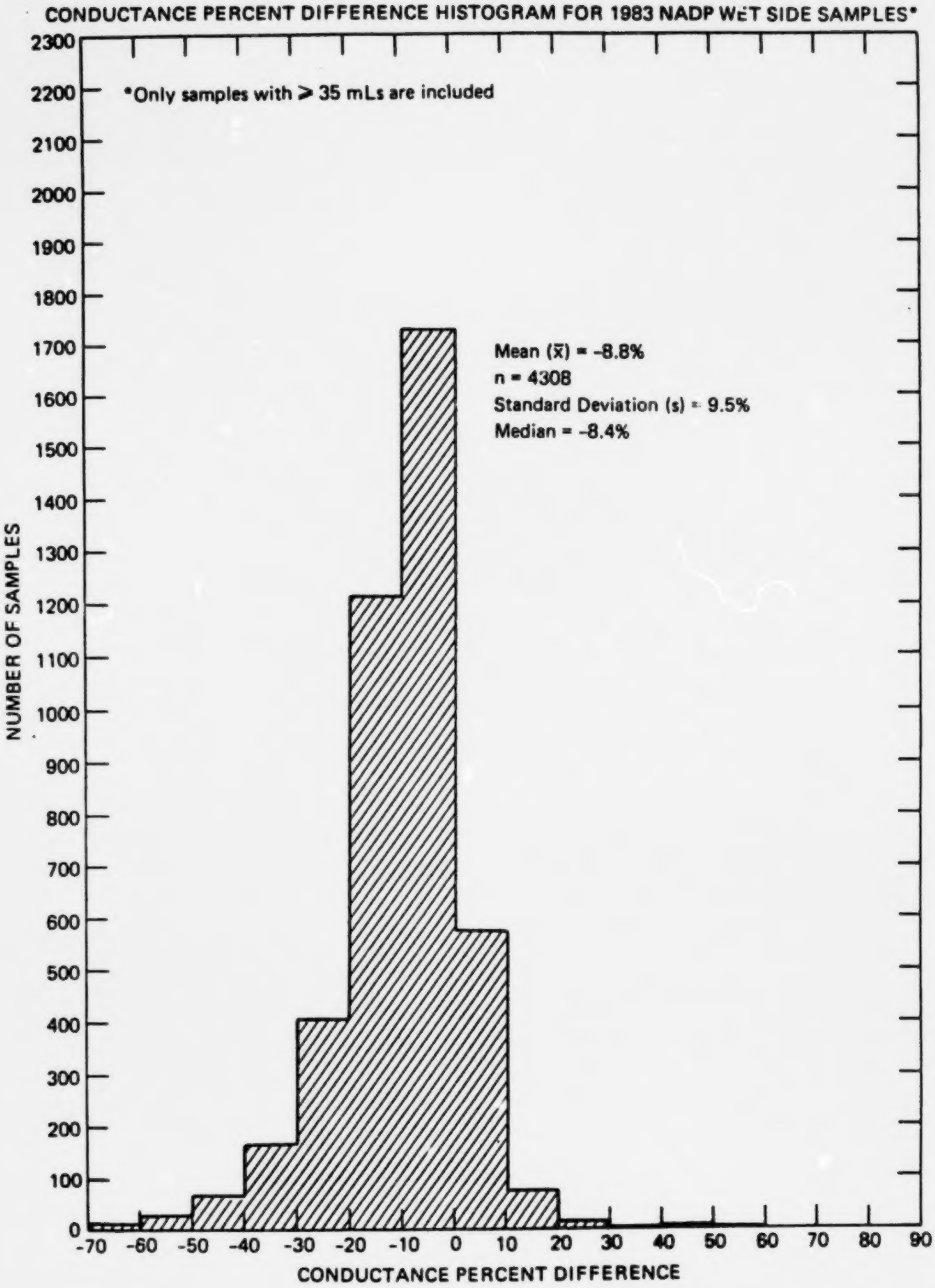


FIGURE V-4. Conductance percent difference histogram for NADP/NTN wet side samples in 1983.

and the specific conductance values obtained for quality control samples with certified conductivity values are consistently within the acceptable limits. This leaves a problem in the calculations as the source of the skewed curve. Using the constants found in the CRC Handbook instead of those in Standard Methods to determine the calculated specific conductance results in a population mean difference closer to 0%. The change to these constants was put into effect beginning in March 1987. This negative skew may also be the result of the presence of ions not being routinely measured at the CAL. The curve is centering near -10% in most years which may result from the presence of low concentrations of ions whose presence go undetected in the IPD calculations and resultant histograms. The presence of very trace amounts of metal ions complexed with unmeasured anions, such as bromide, could go undetected by the ion balance calculation but result in a negative conductance percent difference.

D. Discussion of Results

The fact that a sample does not satisfy the criteria previously described and is selected by the program for reanalysis does not necessarily mean it will be reanalyzed. Reanalysis may be impossible simply because all of the sample was used during the initial analyses. Also, splits are not reanalyzed if the original duplicate analyses were the same or very similar to each other. All other samples flagged by the ion balance program are retrieved and reanalyzed for all constituents.

Once the reanalysis has been completed, the new data are compared to the original data. When substantial differences are found between the two results, reasons for the difference are sought. The first step is to analyze the refrigerated aliquot when one is available. Since refrigeration is a means of sample preservation, the integrity of the refrigerated aliquot should have been maintained. If the difference was the result of decomposition of the sample stored at room temperature, it will be apparent. When the results from the analysis of the refrigerated aliquot are more like the reanalysis value, the source of the error in the original analysis is sought. Analyst's input as to the possible source of error is always requested and utilized to explain discrepancies between original and reanalysis results.

When a difference in original and reanalysis values occurs and no explanation can be found, the original data are reported. If the difference is explained, the data will be changed and a new value reported. For all of the samples reanalyzed, less than one percent will require any change in the original data. The overall result is approximately 0.1% of the final data changed from what was initially reported.

VI. EXTERNAL QUALITY ASSURANCE PROGRAM PARTICIPATION

The analytical bias and precision information reported in Section IV and Appendix D of this report are supported by the CAL's performance in several different external quality assurance programs. The U.S. Geological Survey has accepted the position as the external auditing agency of the CAL for the national monitoring network. In addition to this external quality assurance program, the CAL voluntarily participates in other national and international performance studies. In the following section of this report, the performance of the CAL in each of these studies is addressed.

A. U.S. Geological Survey External Audit Program

The U. S. Geological Survey's external audit program for the CAL has two components. These are a blind sample program and an interlaboratory comparison study. The data obtained from each of these programs complement the other by providing additional information about not only the CAL performance but also the effects of the sample handling in the field.

The NADP/NTN Blind Audit Program was started in October 1979 (1). At that time the USGS supplied Standard Reference Water Samples (SRWS) to the sites in the sampling network. The first week a site did not have rain, the site operator was directed to pour this known sample into a clean bucket and submit it to the CAL as the rain sample for the week. The site operator was to also notify the USGS and the Coordinator's Office that the SRWS had been sent and on what day. The sample would be processed by the CAL as a normal rain sample. This program relies on the cooperation of the site operators. It reflects the effects of the sample handling from the time it is bottled at the USGS until it is analyzed at the CAL.

The audit program focuses on the analytical data obtained from analysis of the samples for calcium, magnesium, sodium, potassium, sulfate and chloride. Many of the SRWS samples used in the program through 1983 have analyte concentrations higher than those found in rainwater and often must be diluted by the laboratory before analysis. Table VI-1 lists the maximum analyte concentration that can be present in a sample before a dilution prior to analysis is necessary. The fact that a dilution of the sample has been made adds another variable to be considered when interpreting the data. A report on the information obtained from the program has been prepared by Schroder, et al.(8).

The USGS interlaboratory comparisons were started in the late fall of 1982. Participants in the study were: Inland Waters Directorate, Ontario, Canada (IWD); Illinois State Water Survey, Champaign, Illinois (CAL); U.S. Geological Survey National Water Quality Laboratory, Atlanta, Georgia (ATL); and U.S. Geological Survey National Water Quality Laboratory, Denver, Colorado (DEN). The study was designed to determine if the four test laboratories were producing comparable results, document an analytical bias for each lab, and estimate analytical precision. Precipitation samples from sites in the NADP/NTN network were split at the CAL and sent to the USGS Central Laboratory in Denver. The samples were then distributed to each of the four participants for analysis. Data obtained from the analysis of calcium, magnesium, sodium, potassium, ammonium, sulfate, nitrate, chloride, pH, and specific conductance were subsequently returned to the Denver facility. Water-Resources Investigations Report 85-4313 by Brooks, et al.(9) discusses the USGS analysis of the data received from November 1982 - August 1983.

TABLE VI-1 The Maximum Analyte Concentration Measured Before Sample Dilution Is Required.

Analyte	Concentration (mg/L)	Dates
Calcium	3.00	1/79 - 12/83
Magnesium	1.00	1/79 - 12/83
Sodium	1.00	1/79 - 12/83
Potassium	1.00	1/79 - 12/83
Ammonium	2.00	1/79 - 12/83
Sulfate	10.00 9.00	1/79 - 1/83 1/83 - 12/83
Nitrate-Nitrite	5.00	1/79 - 12/83
Chloride	5.00 3.00	1/79 - 4/81 4/81 - 12/83
Orthophosphate	0.100 0.250	1/79 - 1/83 1/83 - 12/83

B. Interlaboratory Comparison Studies

Between 1978 and 1983, the CAL participated in several other interlaboratory performance studies in addition to the USGS sponsored comparison just discussed. These studies were sponsored by state and federal government agencies and international organizations. This section continues with a brief description of the studies in which the CAL participated. The CAL data for each study are presented in tables which also include the expected analyte concentrations. More detailed explanations of the laboratory intercomparisons are contained in the agency summaries referenced at the end of this report.

World Meteorological Organization/ United States Environmental Protection Agency

In an attempt to establish cooperation among international precipitation laboratories and to better evaluate its network data, the World Meteorological Organization (WMO) selected a Precipitation Reference Laboratory (PRL) in 1975. It designated the Environmental Monitoring Systems Laboratory (EMSL) of the U.S. Environmental Protection Agency, Research Triangle Park, N.C. to be this PRL and directed it to achieve the goals it had set by designing and conducting interlaboratory comparison studies. The first WMO sponsored study in which the CAL participated was the Third Intercomparison. Table VI-2 lists the CAL data and the National Bureau of Standards (NBS) expected values. The CAL performance at that time was generally very good at the low analyte concentrations with some potential problem areas at very high analyte concentrations, e.g. a chloride value of 37.7 mg/L instead of the expected 42.4. Rating of each laboratory was not a part of this WMO intercomparison. Overall improvement by all of the participating laboratories since the second intercomparison was the only assessment of laboratory performance made (10).

With the report for the Fourth Interlaboratory Comparison, individual laboratory evaluations were included. Table V1-3 presents the CAL data and the NBS expected values for the two test samples. The analyte concentrations in these samples were closer to those found in precipitation, and the deviation of the CAL results from the expected values was quite small for all analytes.

The CAL data and NBS expected analyte concentrations for the samples in the Sixth and the Seventh Intercomparisons are found in Tables VI-4 and VI-5, respectively. These data indicate continued improvement in the accuracy of the CAL data. This improvement is more clearly evident in the summary presented in Table VI-6. The calculations used to prepare this summary are those used by the WMO in its analysis of individual laboratory performance and are taken from the final report for the Fourth Intercomparison (11) and the report for the intercomparisons performed in 1983 (12). Table VI-6 was first presented in Chapter 10 of Semonin, et al. (13) which discusses in more detail the CAL participation in the WMO studies.

TABLE VI-2 Third Interlaboratory Comparison of Reference Precipitation Samples - December 1978 - Compares CAL Values to NBS Expected Values.

Parameter	Samples 71XXXX CAL	71XXXX Expected	72XXXX CAL	72XXXX Expected	73XXXX CAL	73XXXX Expected
Calcium (mg/L)	0.09	0.08	0.88	0.77	7.2	6.0
Magnesium (mg/L)	0.117	0.110	1.20	1.12	<0.002	-----
Sodium (mg/L)	0.151	0.151	2.71	2.86	9.76	9.66
Potassium (mg/L)	0.193	0.199	0.957	0.994	4.90	4.94
Ammonium (mg/L)	0.13	0.11	1.07	1.07	10.1	10.2
Nitrate (mg/L)	0.44	0.50	3.14	3.02	15.5	14.5
Chloride (mg/L)	0.95	1.35	6.63	7.22	37.7	42.4
Sulfate (mg/L)	3.3	2.7	9.3	7.9	10.2	9.9
pH (units)	4.24	4.48	4.07	4.08	5.75	5.98
Specific Conductance (uS/cm)	27.9	28.8	76.5	77.9	199.1	190.5

TABLE VI-3 Fourth Interlaboratory Comparison of Reference Precipitation Samples - July 1980 - Compares CAL Values to NBS Expected Values.

Parameter	Samples 91XXX CAL	91XXX Expected	92XXX CAL	92XXX Expected
Calcium (mg/L)	0.24	0.25	0.67	0.65
Magnesium (mg/L)	0.056	0.056	0.230	0.226
Sodium (mg/L)	0.282	0.284	0.542	0.554
Potassium (mg/L)	0.146	0.156	0.488	0.506
Ammonium (mg/L)	0.22	0.21	0.70	0.66
Nitrate (mg/L)	0.84	0.82	2.17	2.15
Chloride (mg/L)	0.98	0.91	3.29	3.27
Sulfate (mg/L)	0.84	0.78	2.73	2.32
pH (units)	5.06	5.03	4.28	4.35
Specific Conductance (uS/cm)	10.8	9.9	39.1	38.5

TABLE VI-4 **Sixth Interlaboratory Comparison of Reference Precipitation Samples - April 1983 - Compares CAL Values to NBS Expected Values.**

Parameter	Samples					
	1XXX		2XXX		3XXX	
	CAL	Expected	CAL	Expected	CAL	Expected
Calcium (mg/L)	0.06	0.06	0.42	0.40	0.14	0.15
Magnesium (mg/L)	0.02	0.02	0.08	0.08	0.06	0.06
Sodium (mg/L)	0.24	0.25	1.75	1.83	1.23	1.36
Potassium (mg/L)	0.08	0.08	0.81	0.80	0.51	0.55
Ammonium (mg/L)	0.17	0.14	1.06	1.11	0.45	0.41
Nitrate (mg/L)	0.66	0.62	3.65	3.34	3.72	3.72
Chloride (mg/L)	0.39	0.40	2.84	2.82	1.06	1.15
Sulfate (mg/L)	1.74	1.80	13.4	12.79	6.23	6.32
pH (units)	4.48	4.51	3.48	3.51	3.93	3.92
Specific Conductance (uS/cm)	18.2	17.1	165.3	156.0	66.1	65.5

TABLE VI-5 **Seventh Interlaboratory Comparison of Reference Precipitation Samples - November 1983 - Compares CAL Values to NBS Expected Values.**

Parameter	Samples					
	1XXX		2XXX		3XXX	
	CAL	Expected	CAL	Expected	CAL	Expected
Calcium (mg/L)	0.11	0.11	3.35	3.63	1.92	2.06
Magnesium (mg/L)	0.01	0.01	0.38	0.37	0.25	0.25
Sodium (mg/L)	0.07	0.08	1.49	1.44	0.25	0.26
Potassium (mg/L)	0.05	0.05	1.53	1.47	2.71	2.68
Ammonium (mg/L)	0.44	0.43	2.31	2.31	0.45	0.44
Nitrate (mg/L)	0.13	0.13	6.20	6.11	4.52	4.52
Chloride (mg/L)	1.05	1.01	10.12	10.33	4.22	4.17
Sulfate (mg/L)	1.65	1.71	10.7	11.1	17.0	17.7
pH (units)	4.50	4.45	3.75	3.72	3.50	3.49
Specific Conductance (uS/cm)	19.2	19.0	135.9	135.0	153.4	165.8

TABLE VI-6 **Summary of Results from World Meteorological Organization (WMO) Interlaboratory Comparison of Reference Precipitation Samples.**[a]

Intercomparison number	Date	Number of Participating Laboratories (n)	Mean % Difference[b] From Expected value CAL	Mean % Difference[b] From Expected value All Labs
Fourth	7/80	27	4.38	17.67
Sixth	4/83	22	3.89	17.47
Seventh	11/83	22	2.65	23.51

a. Chemical parameters used in the calculation were Ca, Mg, Na, K, NH_4, NO_3, Cl, SO_4, pH, and Specific Conductance.

b. Mean % Difference = $$\frac{\dfrac{|\text{Expected Value} - \text{Reported Value}|}{\text{Expected Value}}}{10 \text{ (constituents)}} \times 100$$

In each of the interlaboratory comparisons, the CAL also determined acidity and trace metal concentrations for the test samples. Information regarding these analyses can be found in the final reports for each study.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

In December of 1981 the Analytical Chemistry Unit of the Illinois State Water Survey, of which the CAL laboratory is a part, received certification as an environmental laboratory from the Illinois Environmental Protection Agency (IEPA). As part of the certification procedure, a team of reviewers from the IEPA inspected the facilities and interviewed the staff to determine if the regulations set by the IEPA were being followed (14). Analysis of performance evaluation samples containing the parameters for which certification was requested, was also required. Each laboratory was rated satisfactory or unsatisfactory for every analytical value it reported. Information regarding the true or expected values for the analytes present in the test samples was not made available to the participants. The CAL received a satisfactory rating for all values reported.

This certification was for chemical analysis of public water supply samples; however, the parameters that were certified included those found in precipitation and the analytical methods were those used by the CAL. The CAL laboratory staff were among those interviewed and were responsible for most of the analytical data reported.

The certification was valid for two years and recertification was requested in 1983. The on-site review of the laboratory, its staff, and the analytical methods being used, took place in September and the new Certificate of Approval was issued in December 1983.

CANADA CENTRE FOR INLAND WATERS (CCIW)

The Canadian Long Range Transport of Atmospheric Pollutants (LRTAP) program began interlaboratory comparability studies in December 1982 (15). The first study in which the CAL participated was Study L4 which took place in August 1983. The CAL and 35 Canadian laboratories were asked to analyze 11 water samples that included natural waters, precipitation, and synthetic internal reference waters, for all the parameters which were routinely analyzed by the individual labs. Median concentrations for each parameter were determined using the data reported by the 36 participating laboratories. This became the target value used to judge laboratory performance. Tables VI-7 though VI-9 list the median value and the value reported by the CAL for the 11 test samples.

The agreement between the CAL value and the CCIW median was generally very good. The noticeable exceptions were the nitrate-nitrite analyses. The samples were analyzed by Ion Chromatography and the difference between the CAL reported values and the median was consistently equal to the measured nitrite concentration. This was particularly apparent in sample 11 when the discrepancy between the two results and the nitrite levels were quite large.

All participants received a rating of satisfactory, moderate, or poor with the CAL receiving a satisfactory. The data from and evaluation for all participants can be found in the "LRTAP Intercomparison Study L4" by Aspila and Todd (16).

TABLE VI-7 LRTAP Interlaboratory Comparability Study #4 - August 1983 - CAL Reported Values Compared to CCIW Median Values for Calcium, Magnesium, Sodium, and Potassium.

Sample Number	Calcium (mg/L)		Magnesium (mg/L)		Sodium (mg/L)		Potassium (mg/L)	
	CAL	CCIW	CAL	CCIW	CAL	CCIW	CAL	CCIW
1	0.444	0.442	0.402	0.390	3.12	3.20	0.264	0.260
2	0.457	0.435	0.330	0.310	2.81	2.62	0.208	0.200
3	0.902	0.895	0.453	0.440	3.19	3.10	0.288	0.284
4	0.465	0.443	0.330	0.310	2.72	2.63	0.174	0.170
5	1.82	1.76	0.488	0.470	2.50	2.46	0.173	0.165
6	<0.009	0.040	0.741	0.700	0.722	0.711	1.09	1.09
7	0.304	0.300	0.068	0.070	0.533	0.519	0.347	0.325
8	2.22	2.13	0.626	0.605	0.050	0.060	0.085	0.088
9	1.00	0.970	0.213	0.210	0.216	0.200	0.118	0.120
10	13.3	13.0	2.76	2.70	1.24	1.24	0.508	0.500
11	42.4	42.0	9.3	9.10	18.9	18.95	0.894	0.897

TABLE VI-8 LRTAP Interlaboratory Comparability Study #4 - August 1983 - CAL Reported Values Compared to CCIW Median Values for Chloride, Sulfate, and Nitrate/Nitrite.

Sample Number	Chloride (mg/L)		Sulfate (mg/L)		Nitrate/Nitrite (mg/L)	
	CAL	CCIW	CAL	CCIW	CAL	CCIW
1	4.07	4.06	2.70	2.65	0.18	0.04
2	3.14	3.15	1.75	1.75	0.13	0.02
3	4.50	4.48	7.30	7.10	0.13	0.02
4	3.32	3.26	2.05	1.98	0.13	0.03
5	3.08	2.98	3.74	3.47	0.53	0.40
6	0.81	0.82	3.23	3.03	0.49	0.45
7	1.44	1.45	0.25	0.33	0.09	0.04
8	0.76	0.74	5.60	5.21	2.35	2.28
9	0.62	0.585	5.19	4.80	2.48	2.48
10	1.09	1.17	3.36	3.20	1.37	1.35
11	107.6	104.7	39.0	37.0	4.29	0.15

TABLE VI-9 LRTAP Interlaboratory Comparability Study #4 - August 1983 - CAL Reported Values Compared to CCIW Median Values for pH and Specific Conductance.

Sample Number	pH (units)		Specific Conductance (uS/cm)	
	CAL	CCIW	CAL	CCIW
1	4.62	4.60	31.9	32.2
2	4.49	4.50	30.5	30.8
3	4.11	4.10	55.9	59.0
4	4.61	4.64	28.0	28.9
5	6.07	6.24	26.7	27.6
6	5.08	5.02	18.5	18.6
7	5.60	5.60	7.5	7.97
8	5.98	6.30	25.4	26.8
9	4.31	4.31	33.2	33.9
10	7.36	7.70	88.5	93.2
11	5.91	5.51	418.6	434.0

VII. SUMMARY

When first organized, the NADP established as one of the primary goals of the project the production of analytical data which were of the highest quality. To achieve this end, guidelines and expectations were established for field, laboratory and data management operations. The original guidelines can be found in the NADP Plan of Research (17) that was published in 1982. The NADP Quality Assurance Plan for Deposition Monitoring (18) prepared in 1984 more clearly defines these guidelines and fully documents the requirements of the network regarding all three areas of operation.

The CAL laboratory was directed to produce data whose precision and bias were quantified. Minimum method detection limits were established for all analytical parameters and limits for the variance in accuracy were defined. Finally, complete documentation of all quality assurance procedures in use at the CAL was required as well as annual reports of the information derived from the quality assurance data.

The data presented in this report indicate the CAL has achieved what was required. This report as a whole documents the quality assurance program practices as they have developed. The data tables in Appendix D provide annual assessments of the analytical bias and precision and indicate that the limits set for variance in accuracy were met. The MDLs listed in Table II-1 meet or exceed those required. With this report for 1978-1983, quality assurance data for the early years of the project become available to the data user. The CAL, in conjunction with the NADP/NTN Quality Assurance Manager and the Coordinator's Office, is currently attempting to provide the more recent quality assurance data in a more timely manner and thus meet all of the desired goals of the Quality Assurance Plan.

VIII. REFERENCES

1. Stensland, G.J., R.G. Semonin, M.E. Peden, V.C. Bowersox, F.F. McGurk, L.M. Skowron, M.J. Slater, and R.K. Stahlhut: NADP Quality Assurance Report - Central Analytical Laboratory, Jan. 1979 - Dec. 1979; 1980; Champaign, Illinois.

2. Britton, Paul W., Statistician - U. S. Environmental Protection Agency; EMSL - Cincinnati, Ohio; personal communication.

3. NADP/NTN Annual Data Summary. Precipitation Chemistry In The United States. 1983; NADP/NTN Coordinator's Office; Natural Resource Ecology Laboratory; Colorado State University; Ft. Collins, CO 80523; June 1985.

4. Topol, L.E., M. Lev-On, J. Flanagan, R.J. Schwall, A.E. Jackson: Quality Assurance Manual for Precipitation Measurement Systems; U. S. Environmental Protection Agency; Environmental Monitoring Systems Laboratory; Research Triangle Park, NC 27711; 1985.

5. American Society for Testing and Materials: "Standard Method of Reporting Results of Analysis of Water"; Method D596; 1983 Annual Book of ASTM Standards; p.43.

6. Standard Methods for the Examination of Water and Wastewater; 14th Edition; American Public Health Association; Washington, D.C.; 1976; p. 35.

7. CRC Handbook of Chemistry and Physics; 49th Edition; 1968-1969; CRC Press, Inc.; Boca Raton, Florida; p. D-93.

8. Schroder, L.J., A.W. Bricker, and T.W. Willoughby: Precision and Bias of Selected Analytes Reported by the National Atmospheric Deposition Program and National Trends Network - January 1980 Through September 1984; Water-Resources Investigations Report 85-4275; U.S. Geological Survey; Lakewood, Colorado; 1985.

9. Brooks, M.H., L.J. Schroder, and B.A. Malo: Interlaboratory Comparability Bias and Precision for Four Laboratories Measuring Constituents in Precipitation - November 1982 - August 1983; Water-Resources Investigations Report 85-4313; U.S. Geological Survey; Lakewood, Colorado; 1985.

10. Lampe, R.L., and J.C. Puzak: Third Analysis on Reference Precipitation Samples; World Meteorological Organization; 1980.

11. _____ and J.C. Puzak: Fourth Analysis on Reference Precipitation Samples by the Participating World Meteorological Organization Laboratories; December 1981.

12. Lampe, R.L., B.F. Parr, G. Pratt, O.L. Dowler, and W.J. Mitchell: *National Performance Audit Program - Ambient Air Audits of Analytical Proficiency - 1983*; Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency; Research Triangle Park, N.C. 27711.

13. Semonin, R.G., G.J. Stensland, V.C. Bowersox, M.E. Peden, J.M. Lockard, K.G. Doty, D.F. Gatz, L.C. Chu, S.R. Bachman, and R.K. Stahlhut: *Study of Atmospheric Pollution Scavenging*; Twentieth Progress Report to the U.S. Department of Energy; September 1984.

14. *State of Illinois Rules and Regulations*; Title 35: Environmental Protection; Subtitle A: General Provisions; Chapter II: Environmental Protection Agency; Part 183 - Joint Rules of the Illinois Environmental Protection Agency and the Illinois Department of Public Health: Certification and Operation of Environmental Laboratories; December 1, 1983.

15. Aspila, K.I., and S. Todd: *LRTAP Intercomparison Study L1: Major Ions, Nutrients and Physical Parameters in Water*; National Water Research Institute; Burlington, Ontario; July 1983.

16. ______, and S. Todd: *LRTAP Intercomparison Study L4: Major Ions, Nutrients and Physical Parameters in Water*; National Water Research Institute; Burlington, Ontario; February 1984.

17. Cowling, E.B., J. Fulkerson, K. Huston, and J.H. Gibson: *1977 Plan of Research for NC-141 North Central Regional Project on Atmospheric Deposition: Chemical Changes in Atmospheric Deposition and Effects on Agricultural and Forested Land and Surface Waters in the United States*; Natural Resource Ecology Laboratory; Colorado State University; Ft. Collins, CO 80523; September 1982.

18. *NADP Quality Assurance Plan: Deposition Monitoring*; NADP/NTN Coordinator's Office; Natural Resource Ecology Laboratory; Colorado State University; Ft. Collins, CO 80523; July 1984.

APPENDIX A
Laboratory Blanks
Plots and Tables
1978-1983

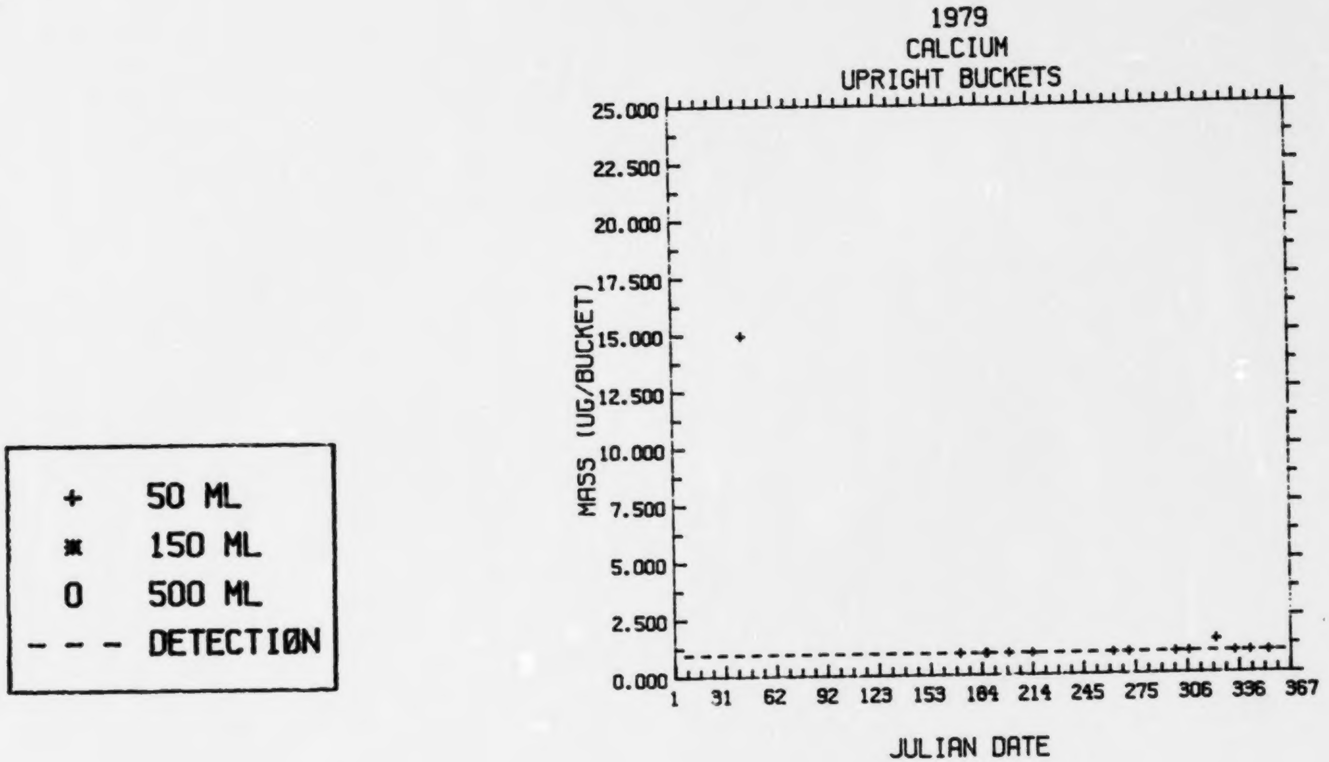


FIGURE 1. Measured calcium mass in upright bucket blanks for 1979.

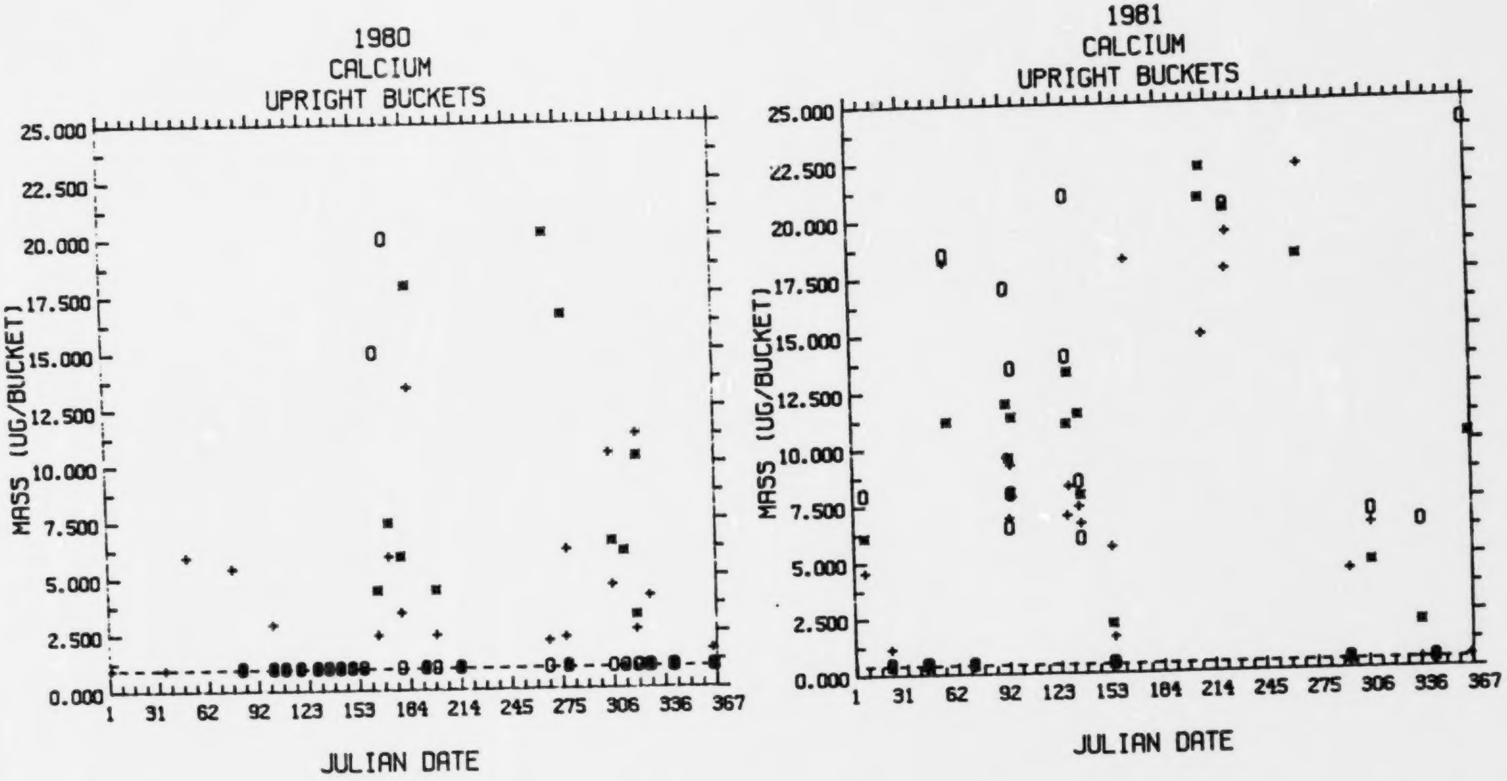


FIGURE 2. Measured calcium mass in upright bucket blanks for 1980 and 1981.

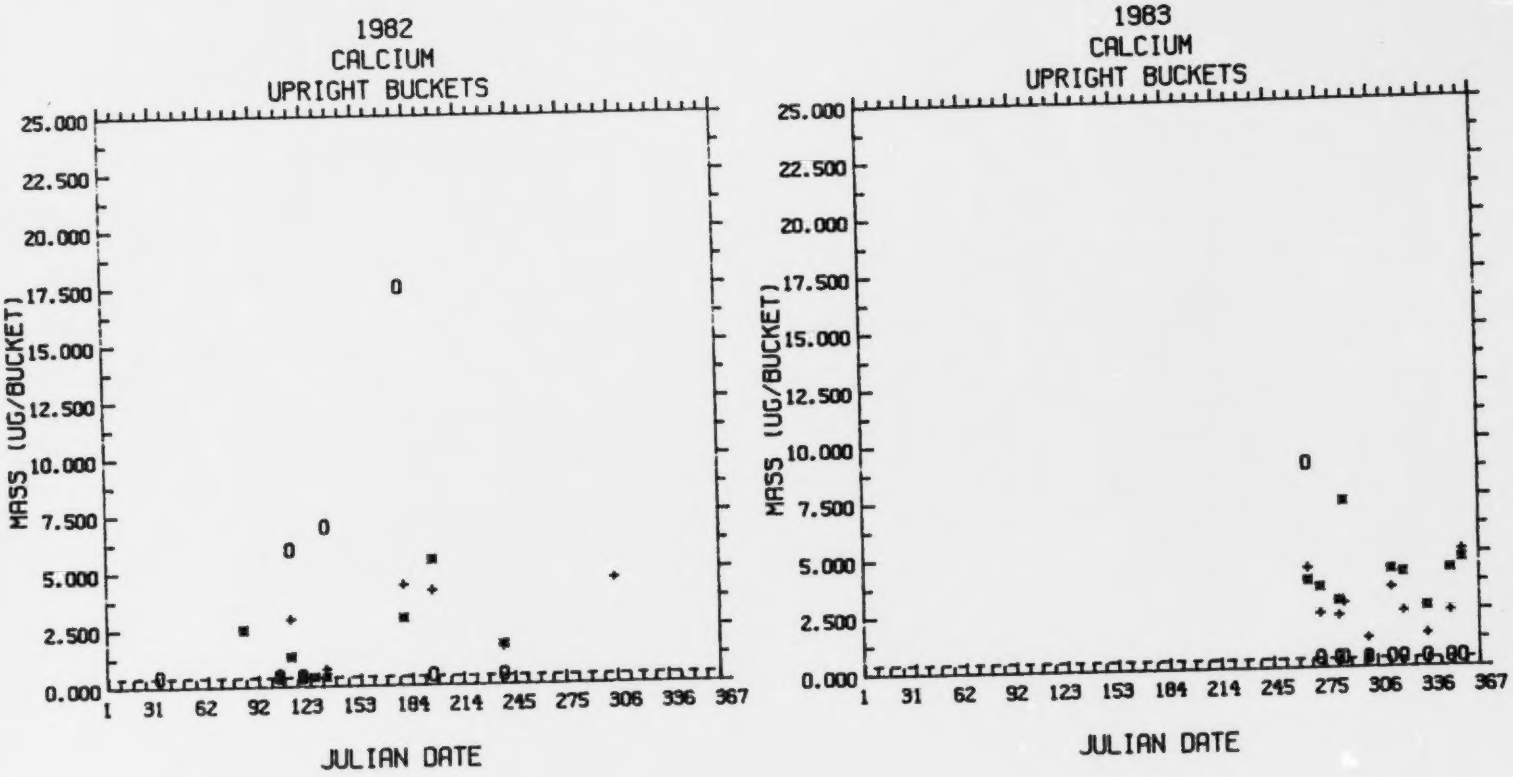


FIGURE 3. Measured calcium mass in upright bucket blanks for 1982 and 1983.

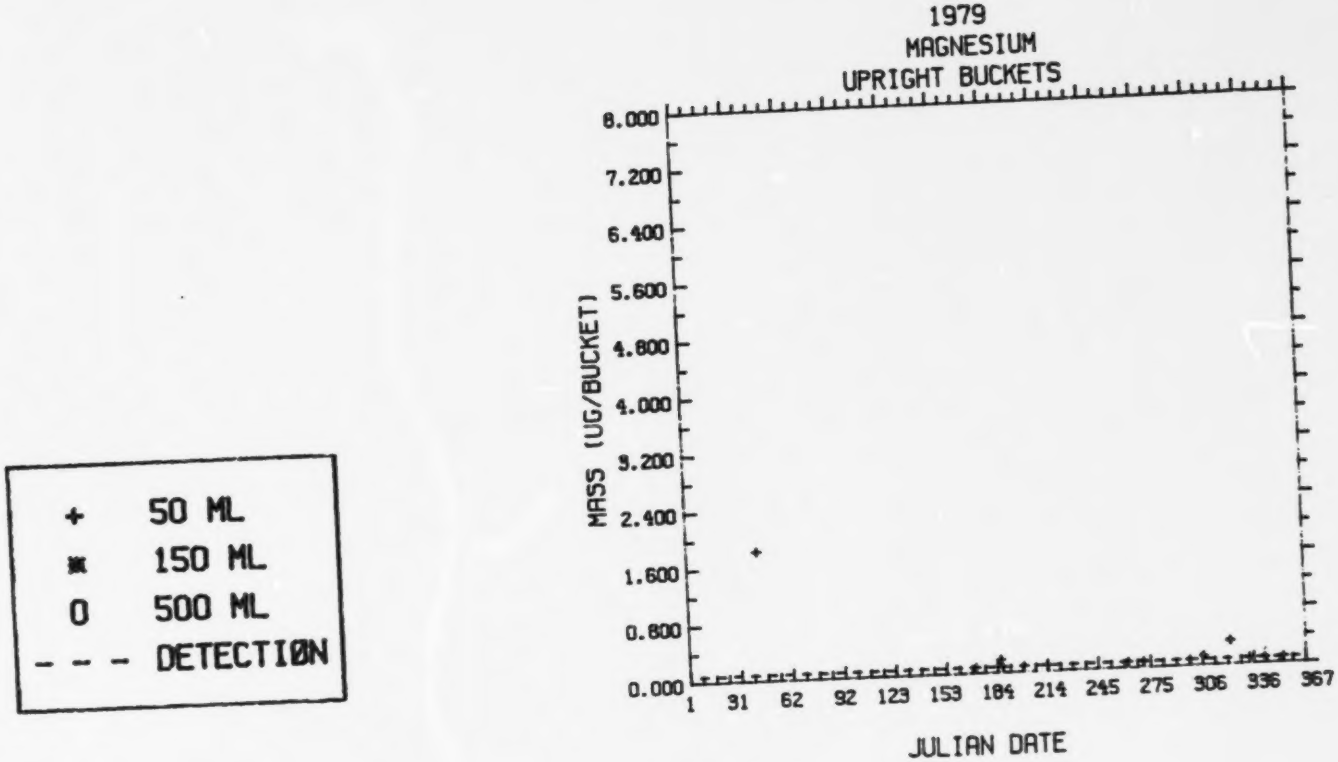


FIGURE 4. Measured magnesium mass in upright bucket blanks for 1979.

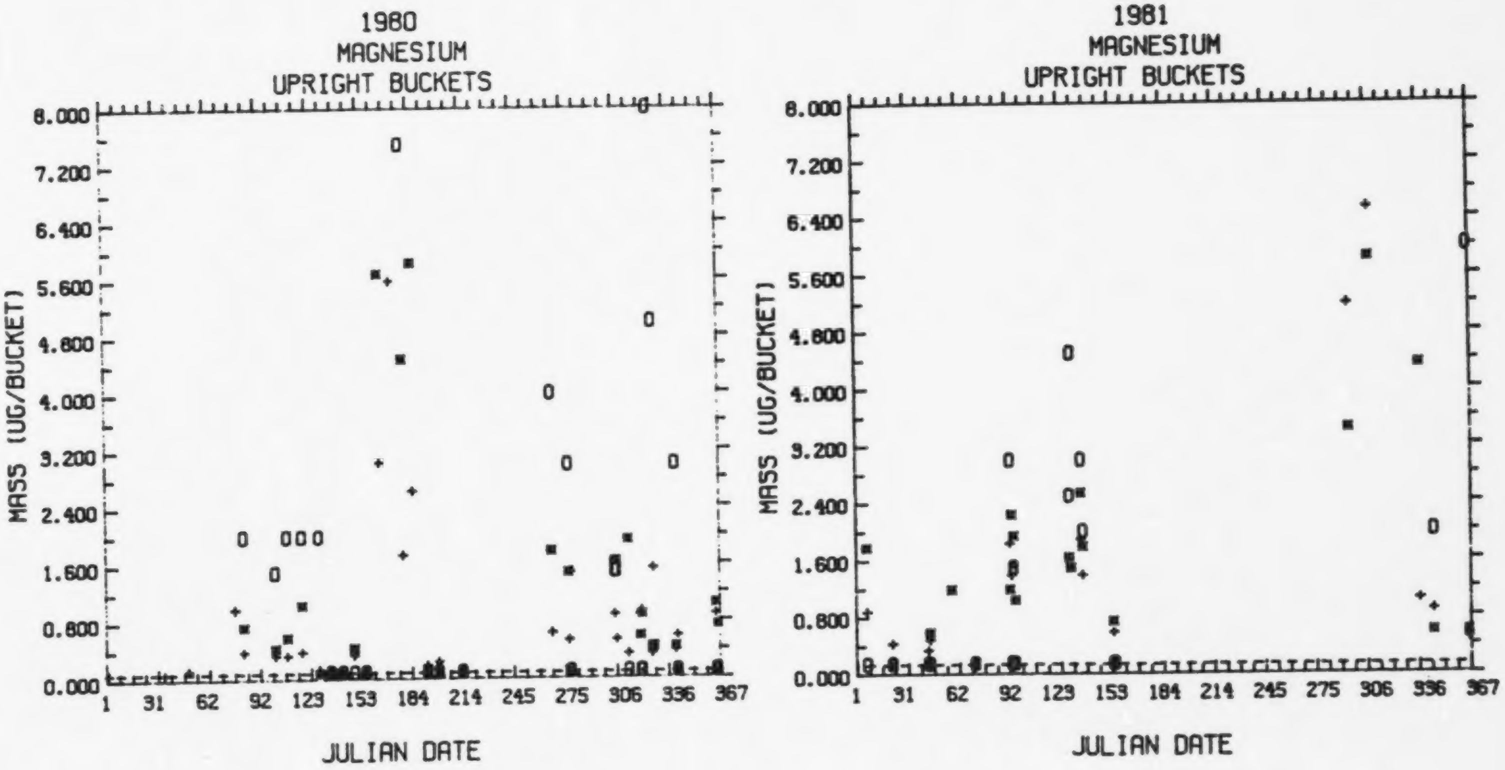


FIGURE 5. Measured magnesium mass in upright bucket blanks for 1980 and 1981.

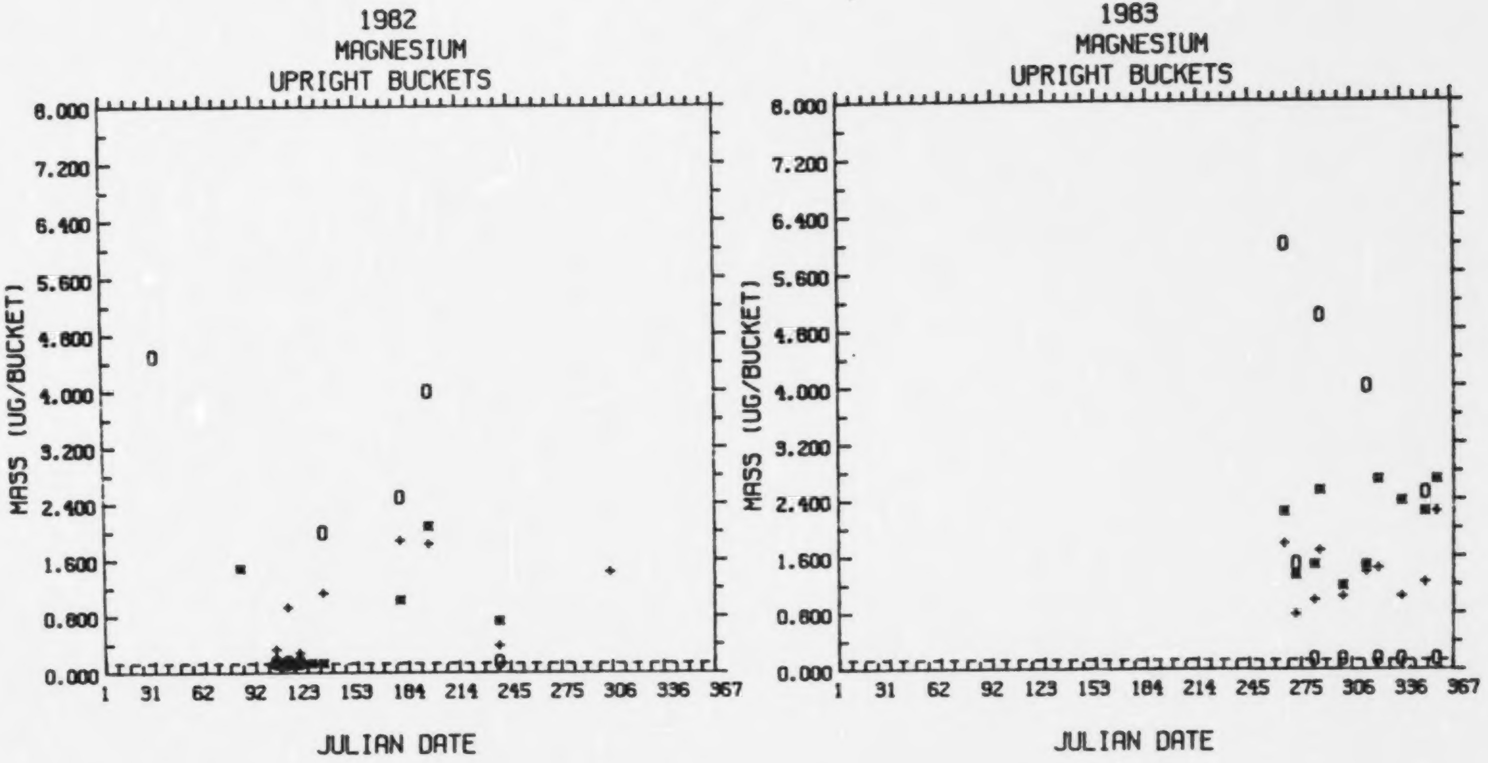


FIGURE 6. Measured magnesium mass in upright bucket blanks for 1982 and 1983.

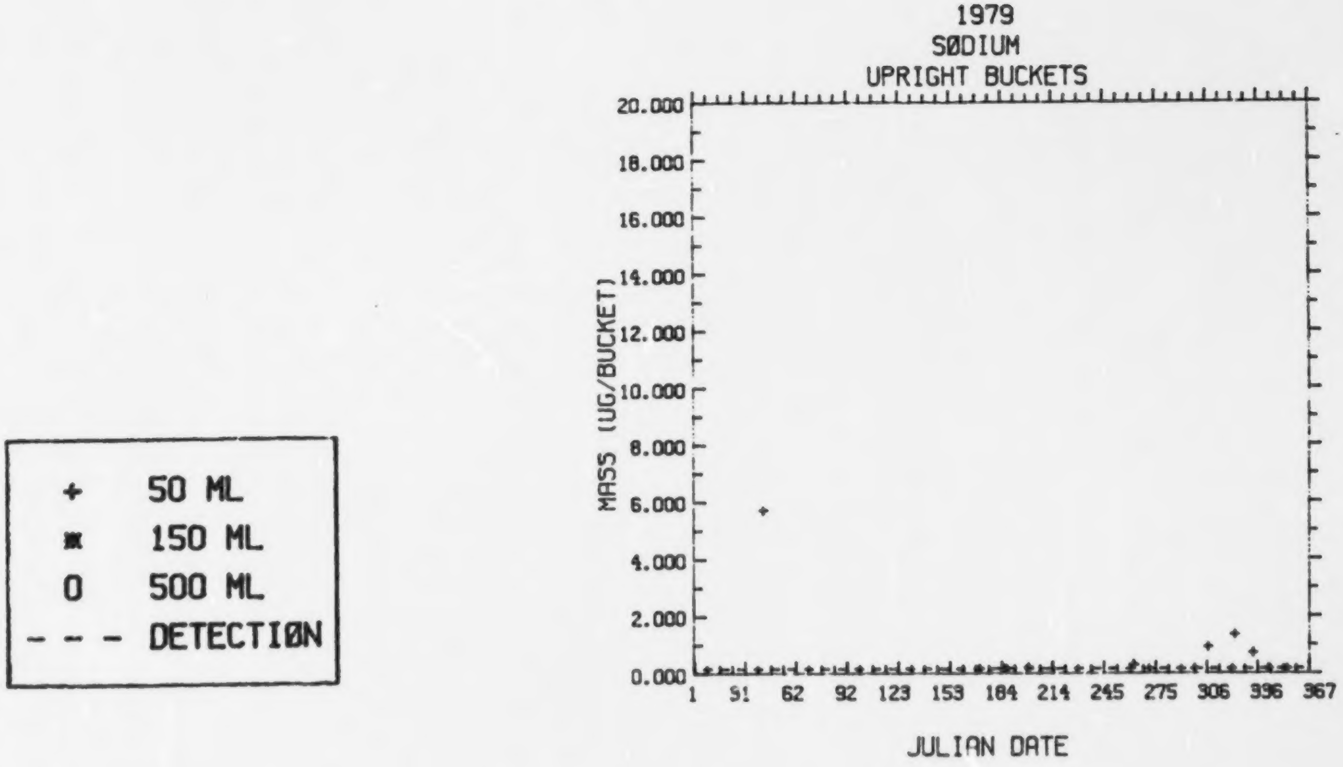


FIGURE 7. **Measured sodium mass in upright bucket blanks for 1979.**

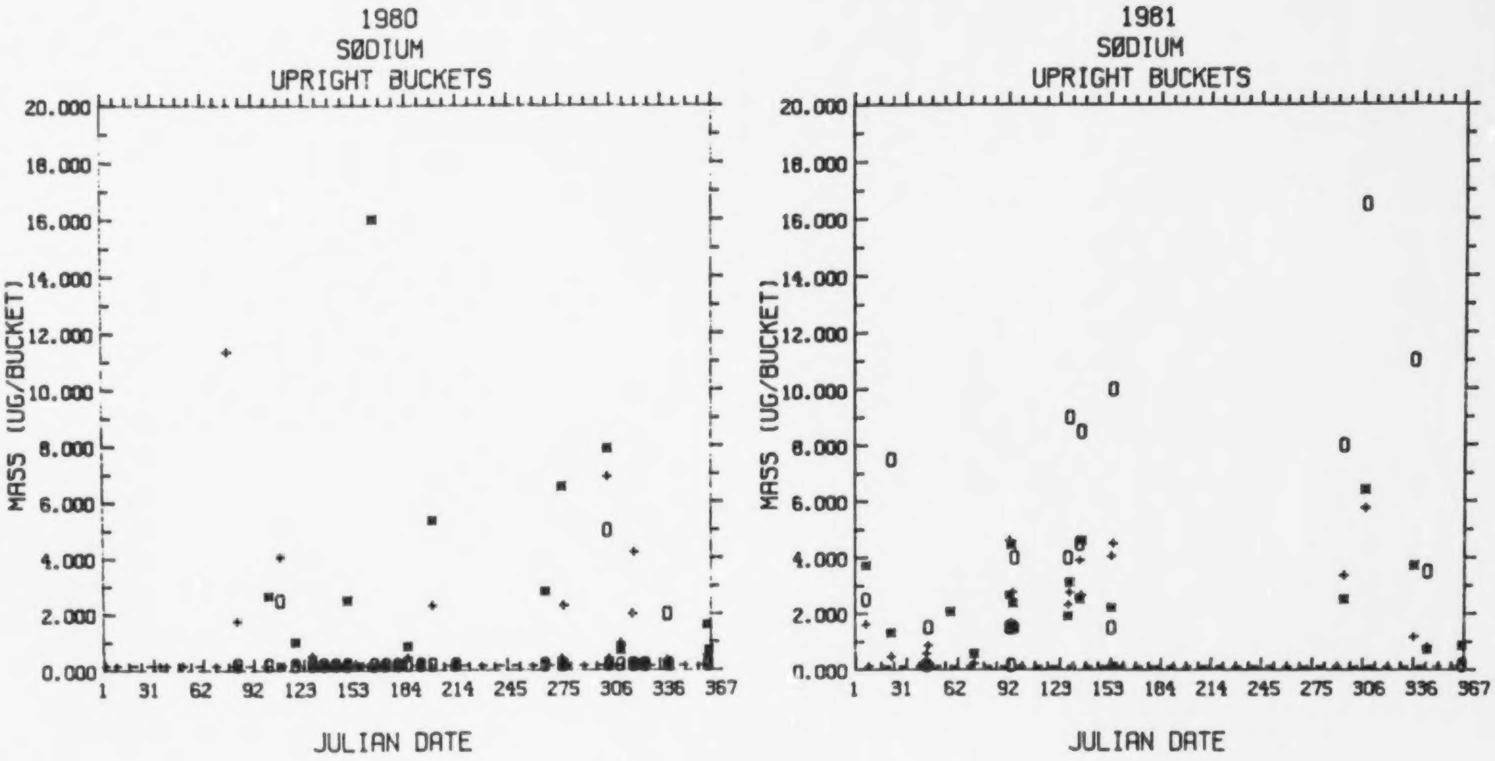


FIGURE 8. Measured sodium mass in upright bucket blanks for 1980 and 1981.

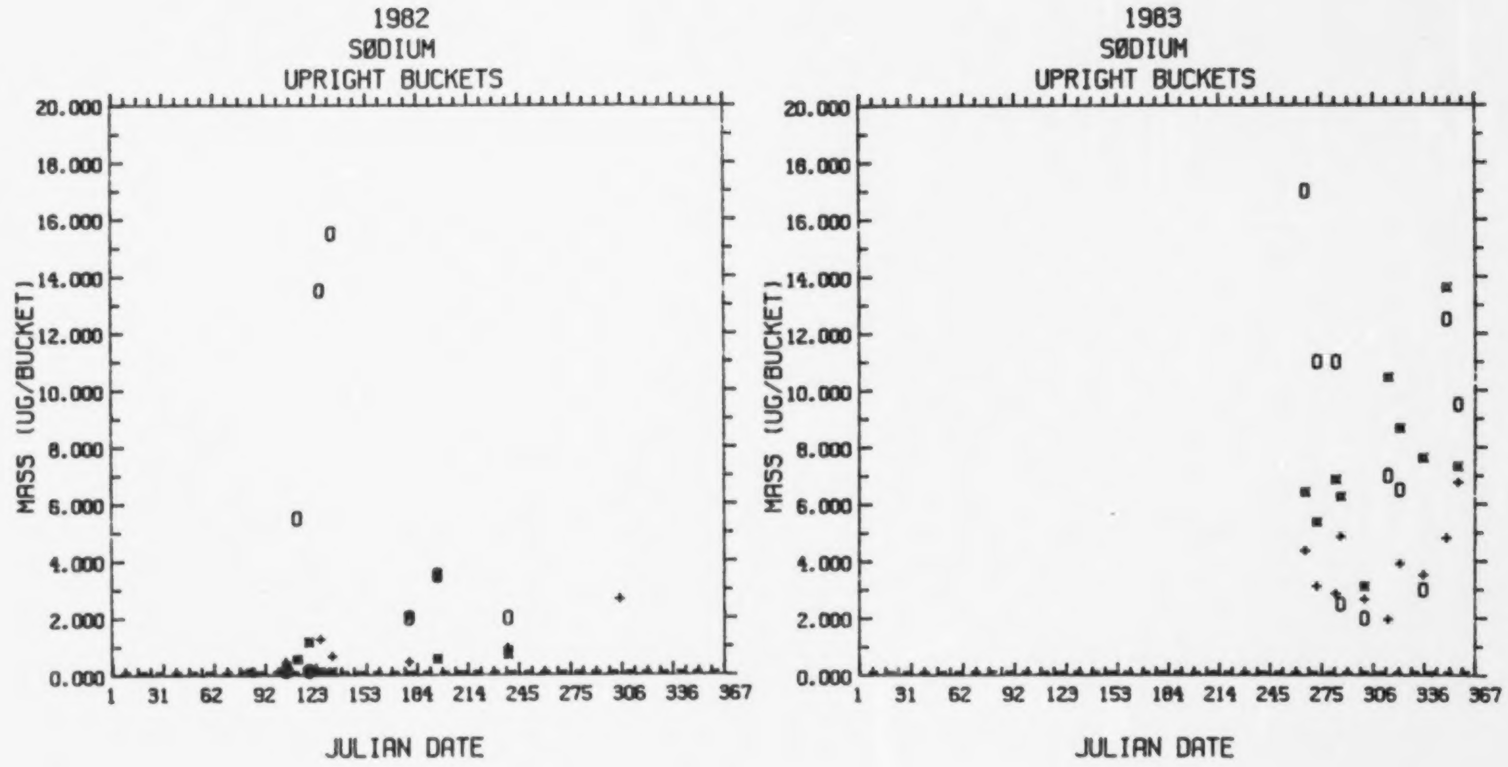


FIGURE 9. Measured sodium mass in upright bucket blanks for 1982 and 1983.

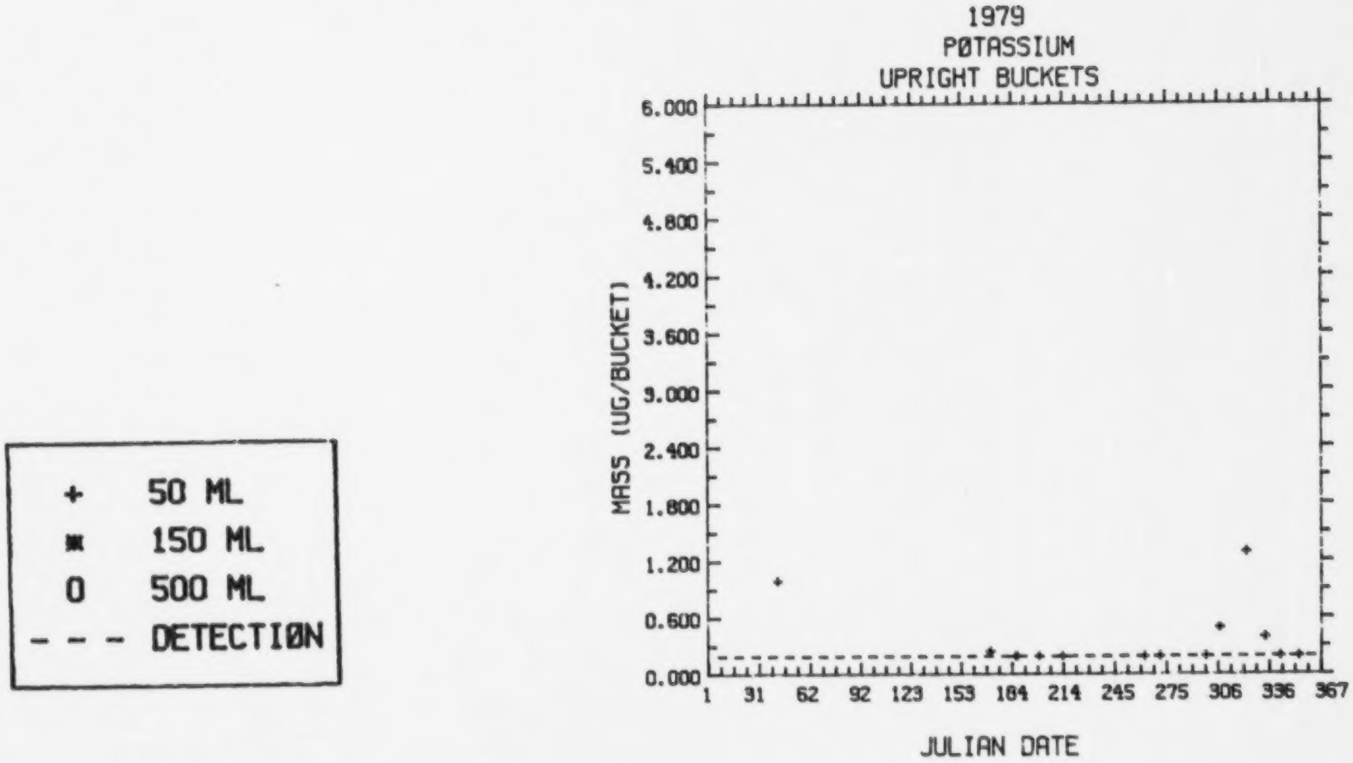


FIGURE 10. Measured potassium mass in upright bucket blanks for 1979.

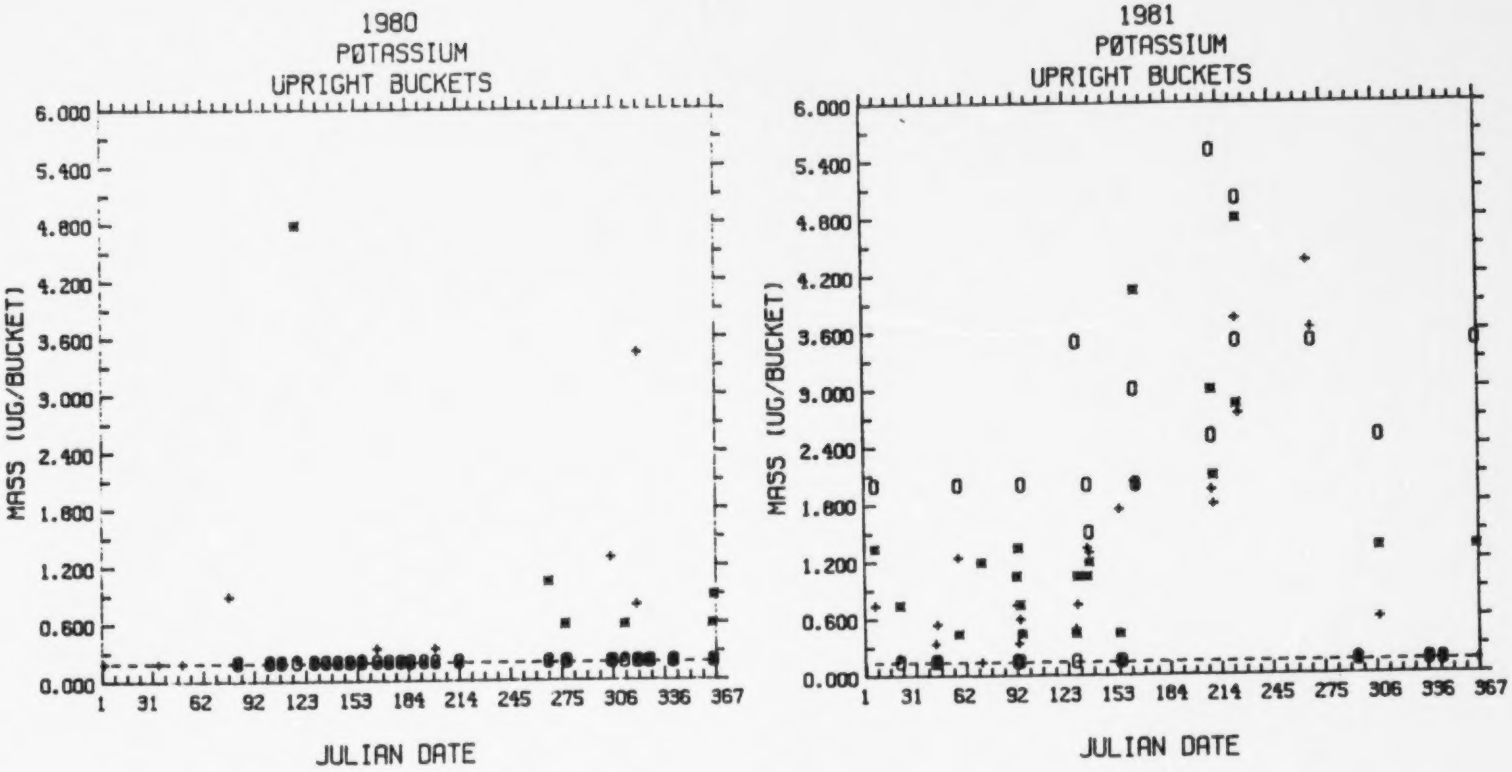


FIGURE 11. Measured potassium mass in upright bucket blanks for 1980 and 1981.

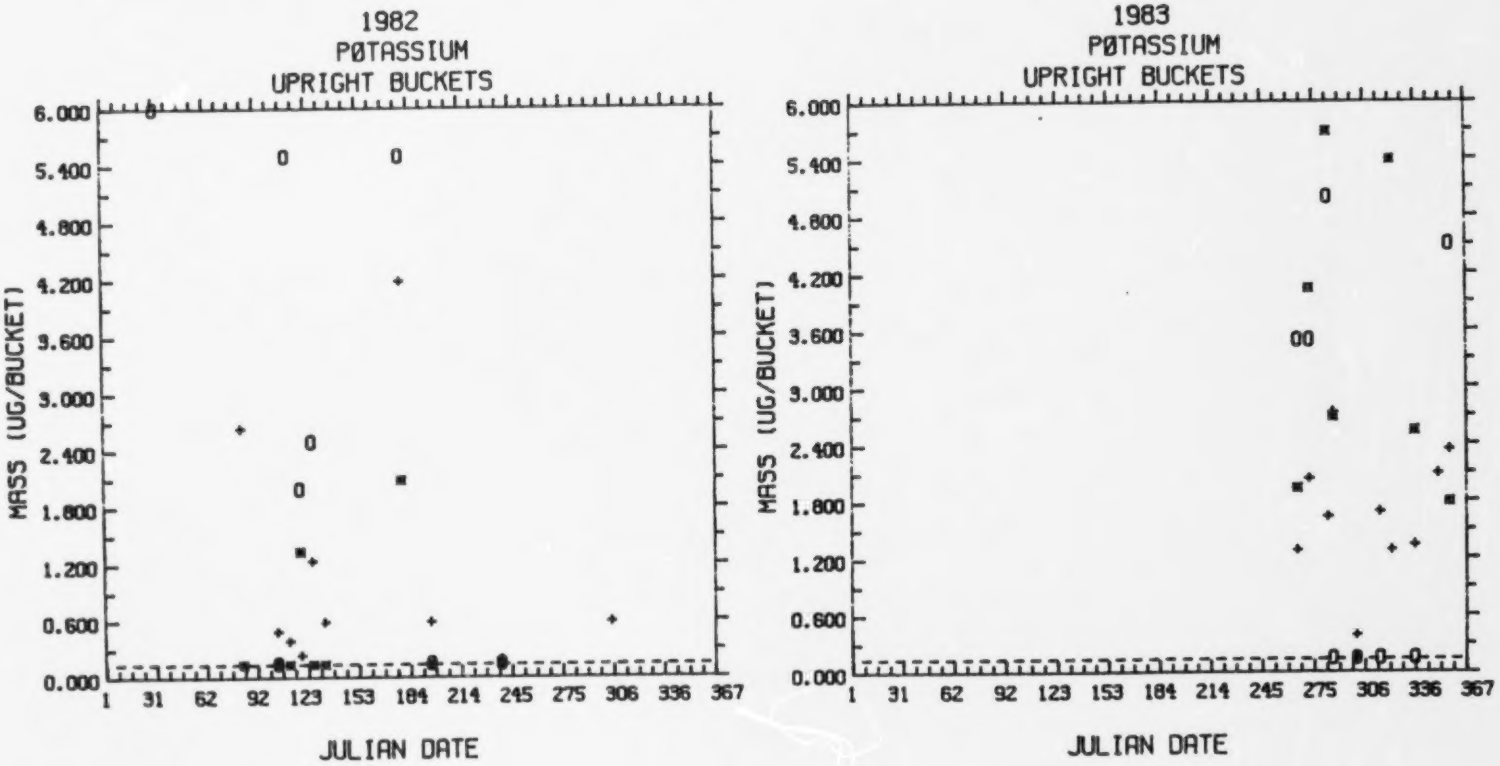


FIGURE 12. Measured potassium mass in upright bucket blanks for 1982 and 1983.

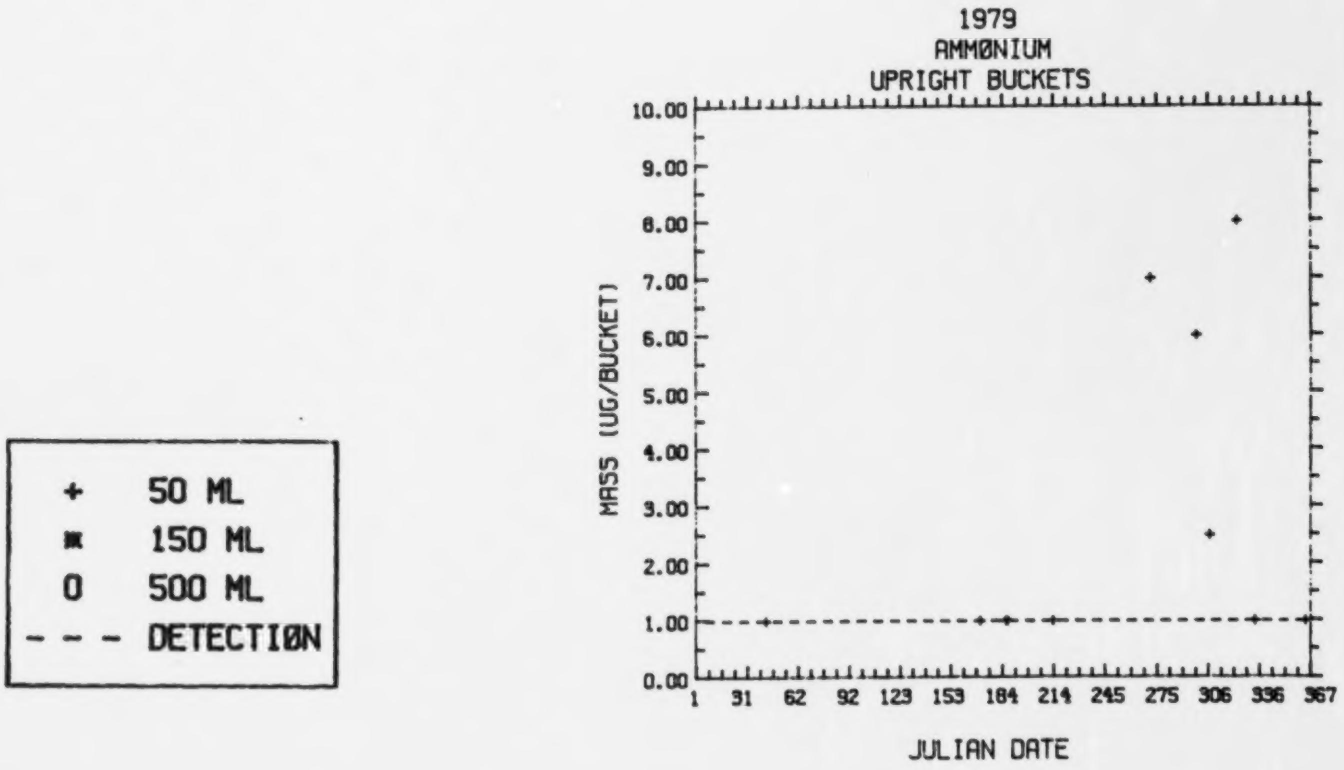


FIGURE 13. Measured ammonium mass in upright bucket blanks for 1979.

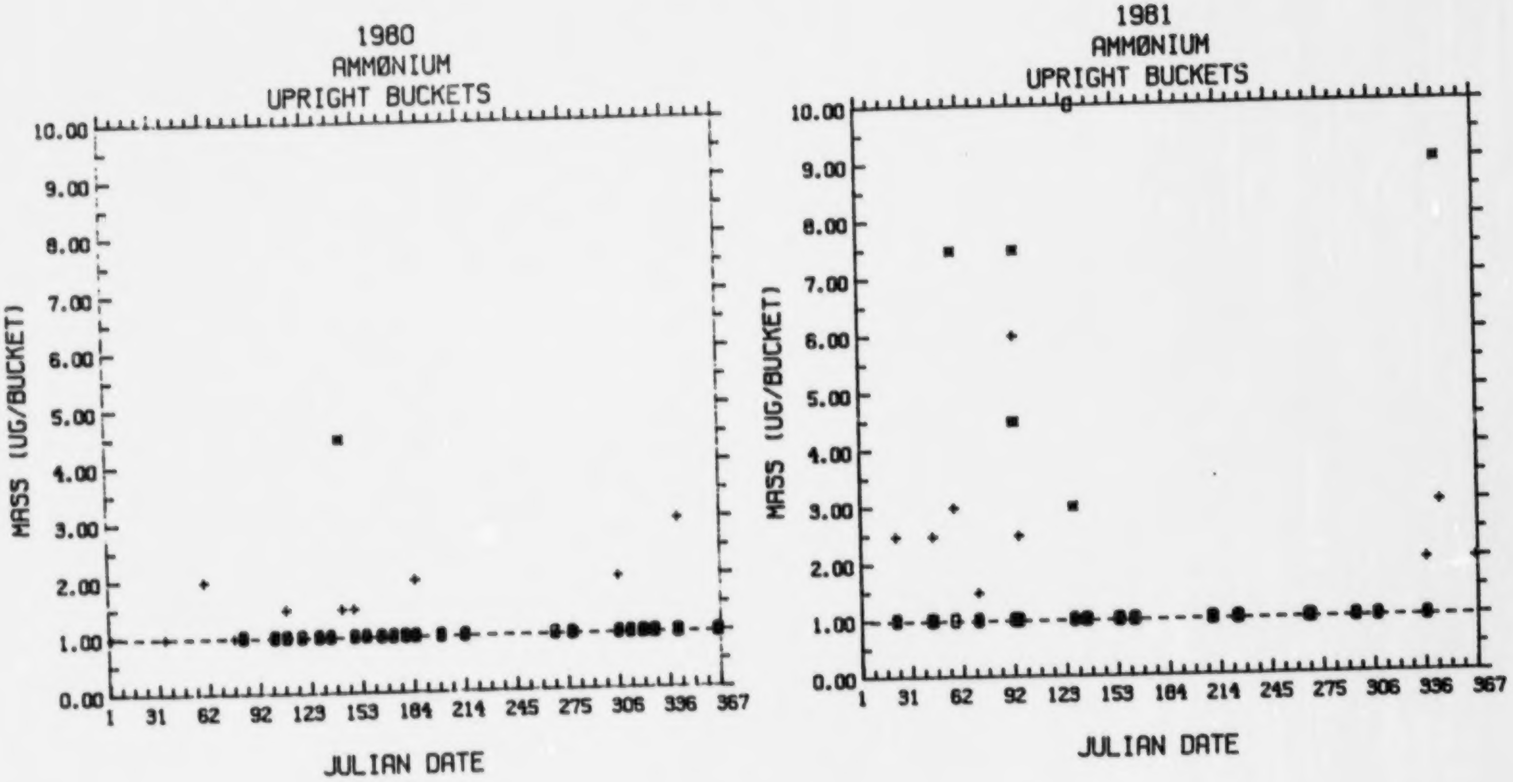


FIGURE 14. Measured ammonium mass in upright bucket blanks for 1980 and 1981.

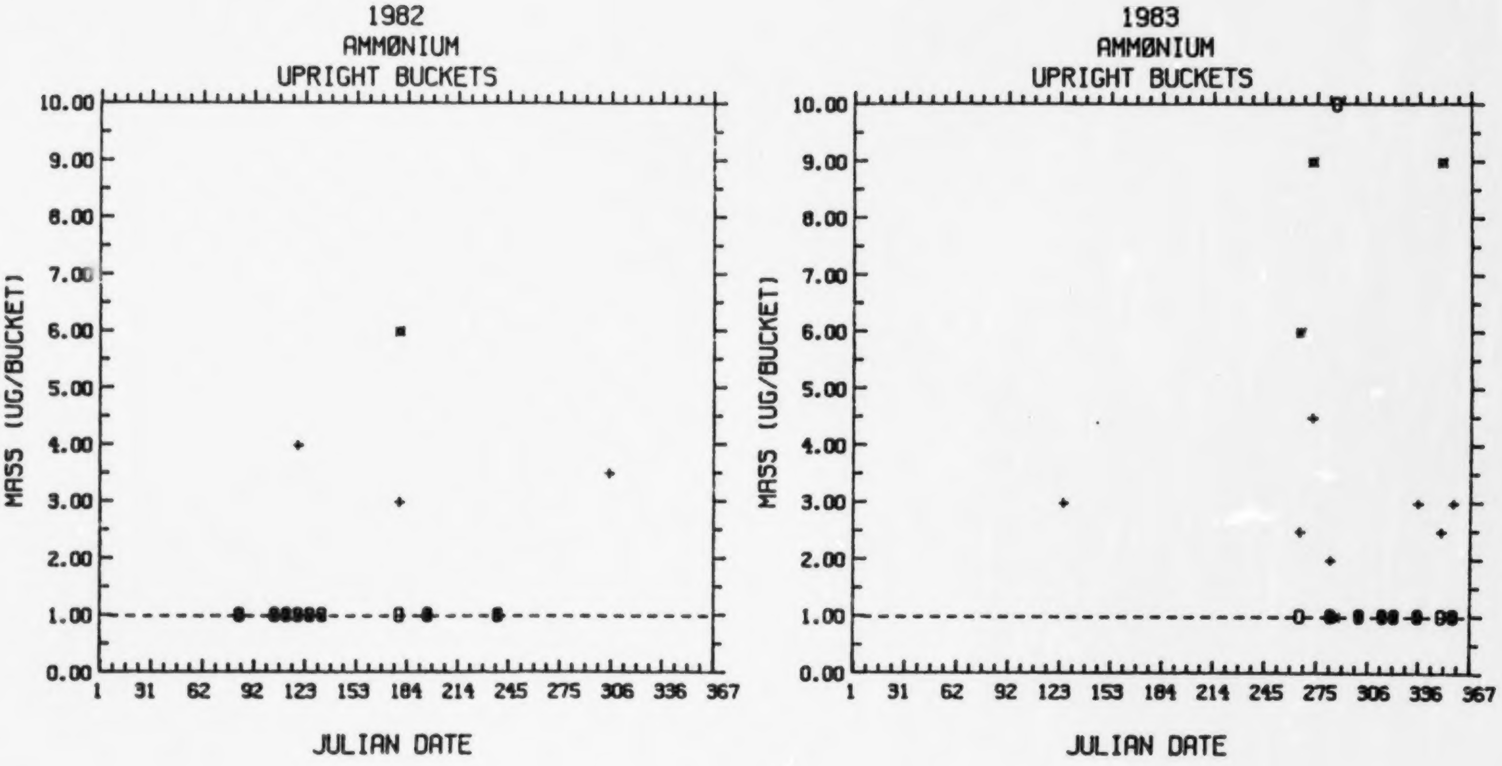


FIGURE 15. Measured ammonium mass in upright bucket blanks for 1982 and 1983.

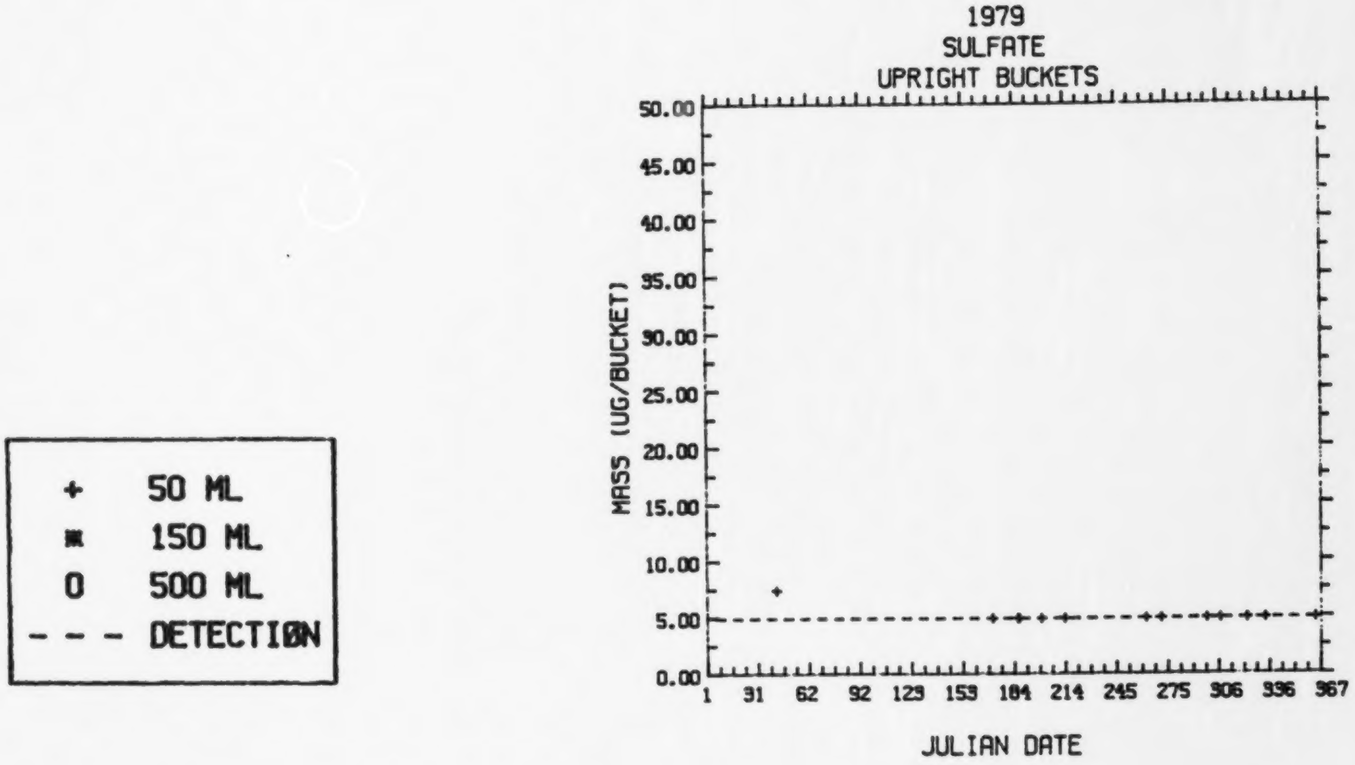


FIGURE 16. Measured sulfate mass in upright bucket blanks for 1979.

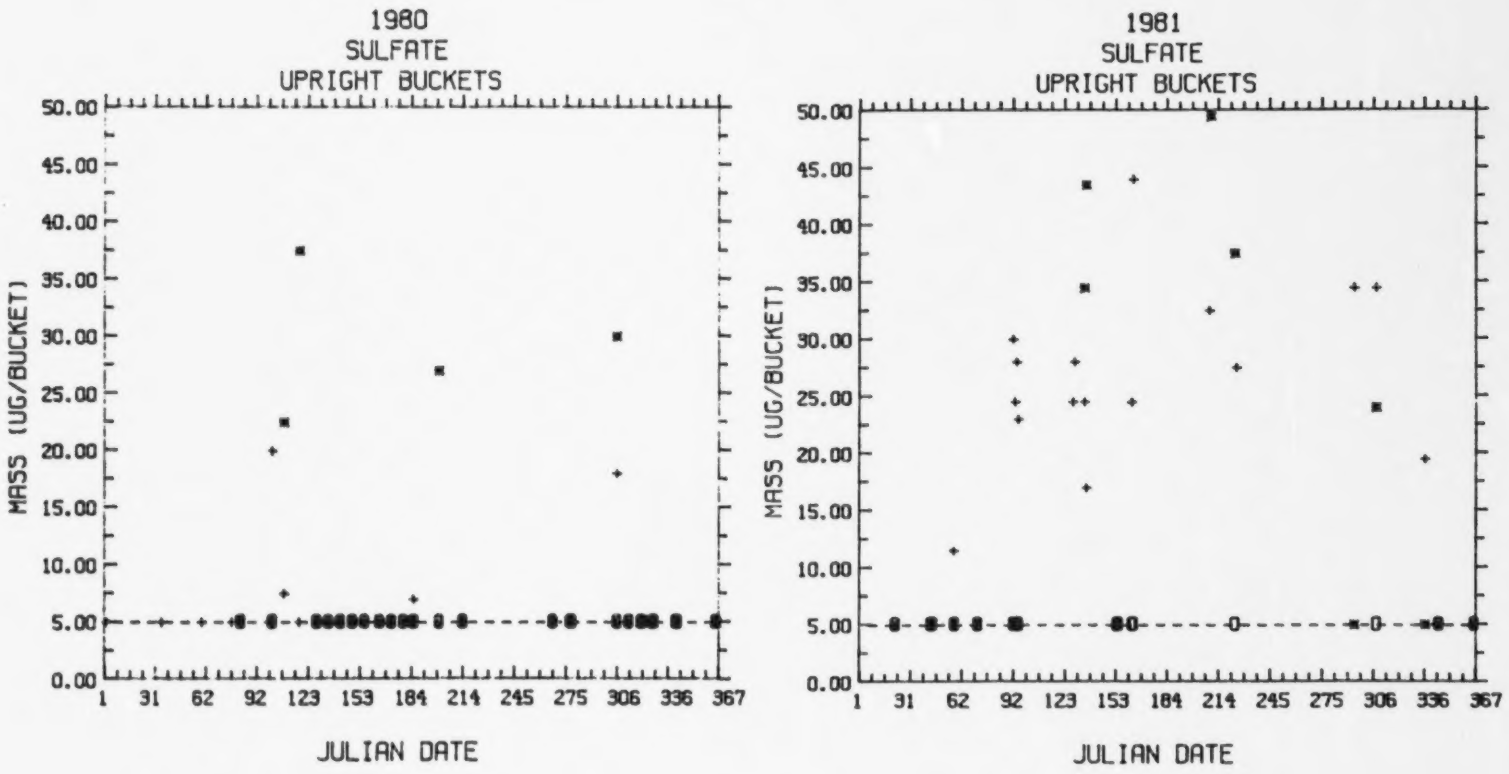


FIGURE 17. Measured sulfate mass in upright bucket blanks for 1980 and 1981.

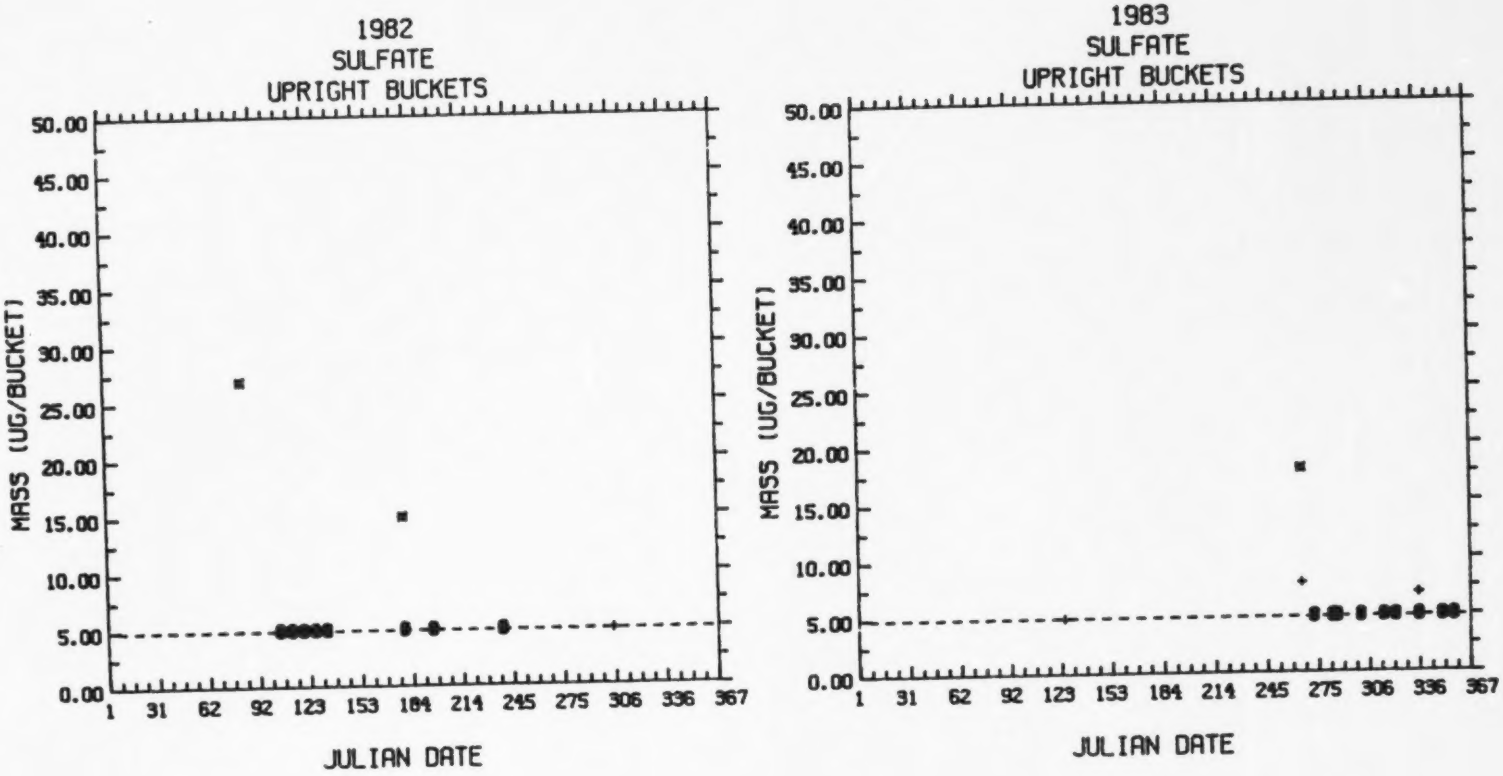


FIGURE 18. Measured sulfate mass in upright bucket blanks for 1982 and 1983.

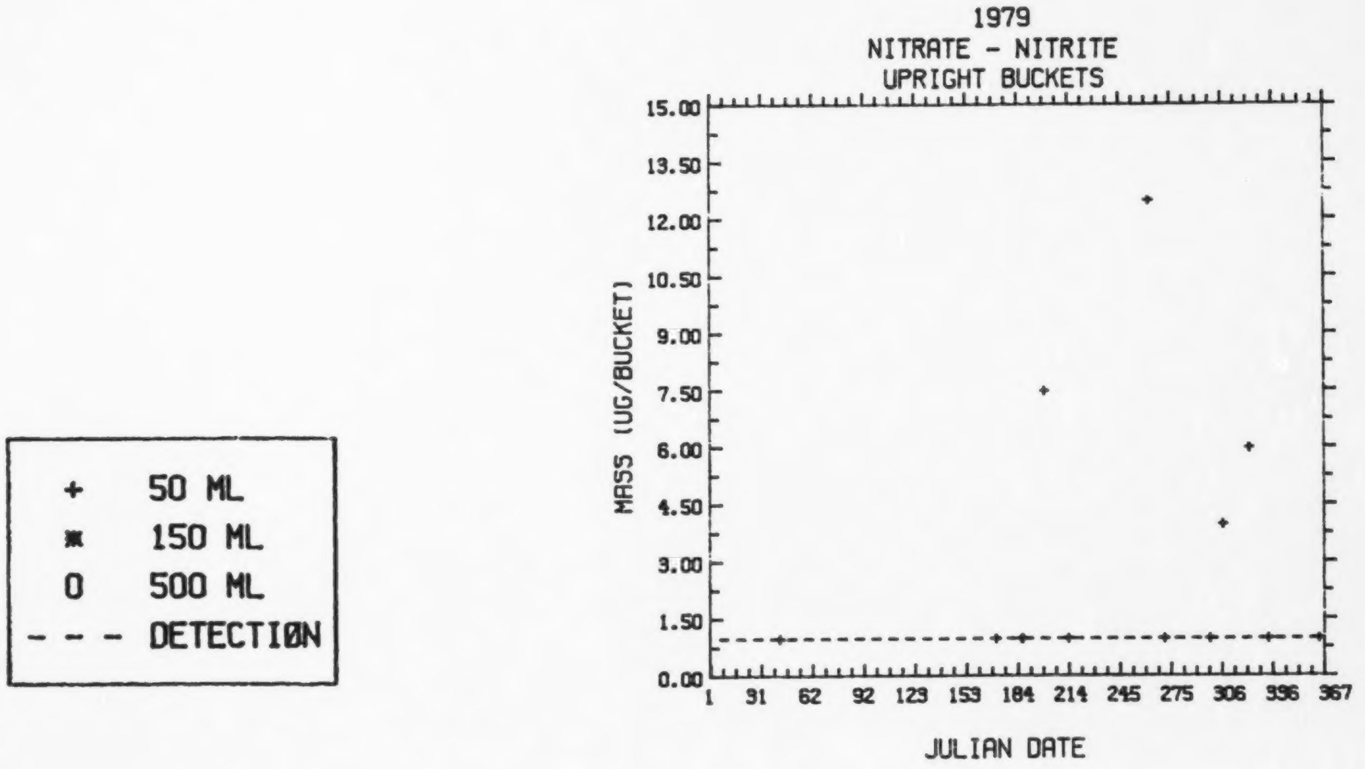


FIGURE 19. Measured nitrate-nitrite mass in upright bucket blanks for 1979.

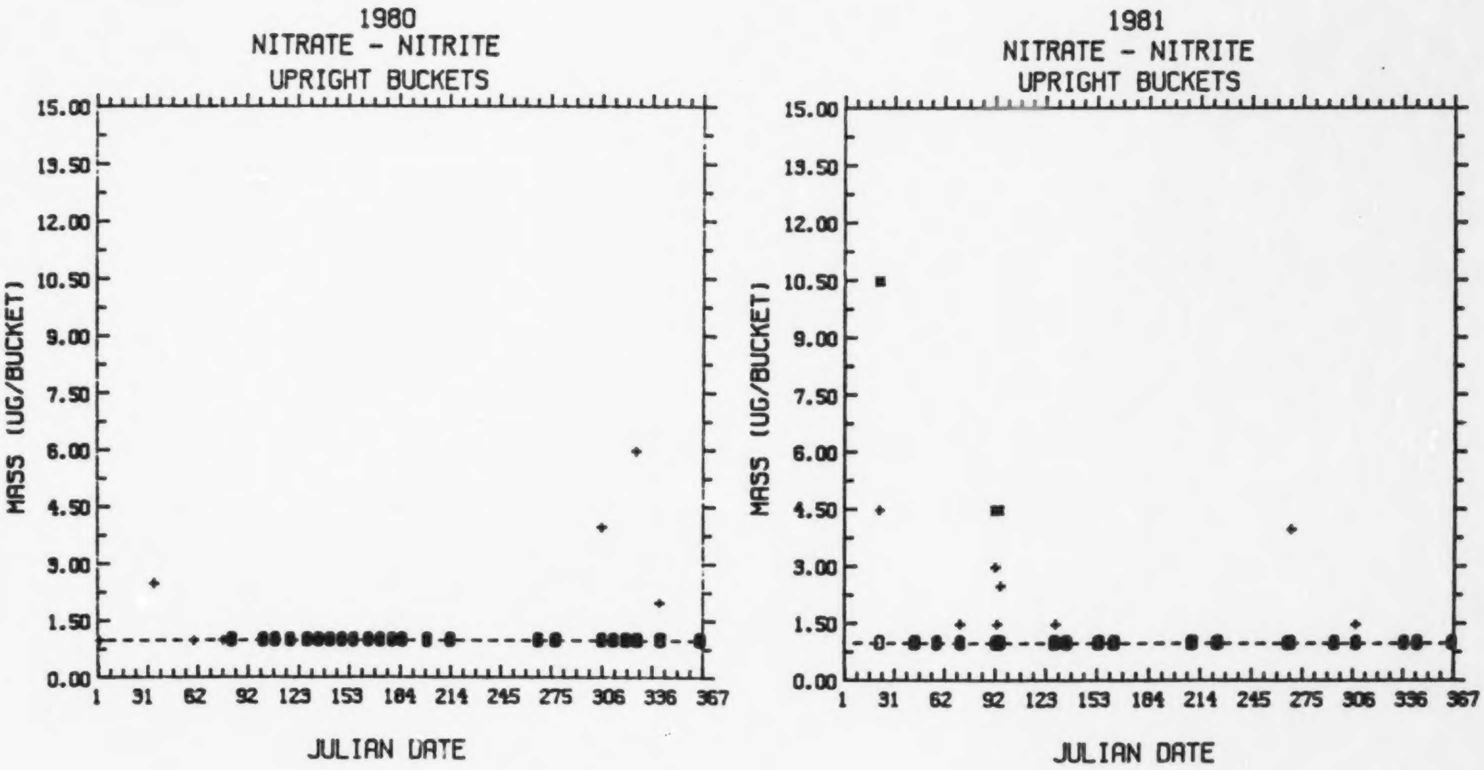


FIGURE 20. Measured nitrate-nitrite mass in upright bucket blanks for 1980 and 1981.

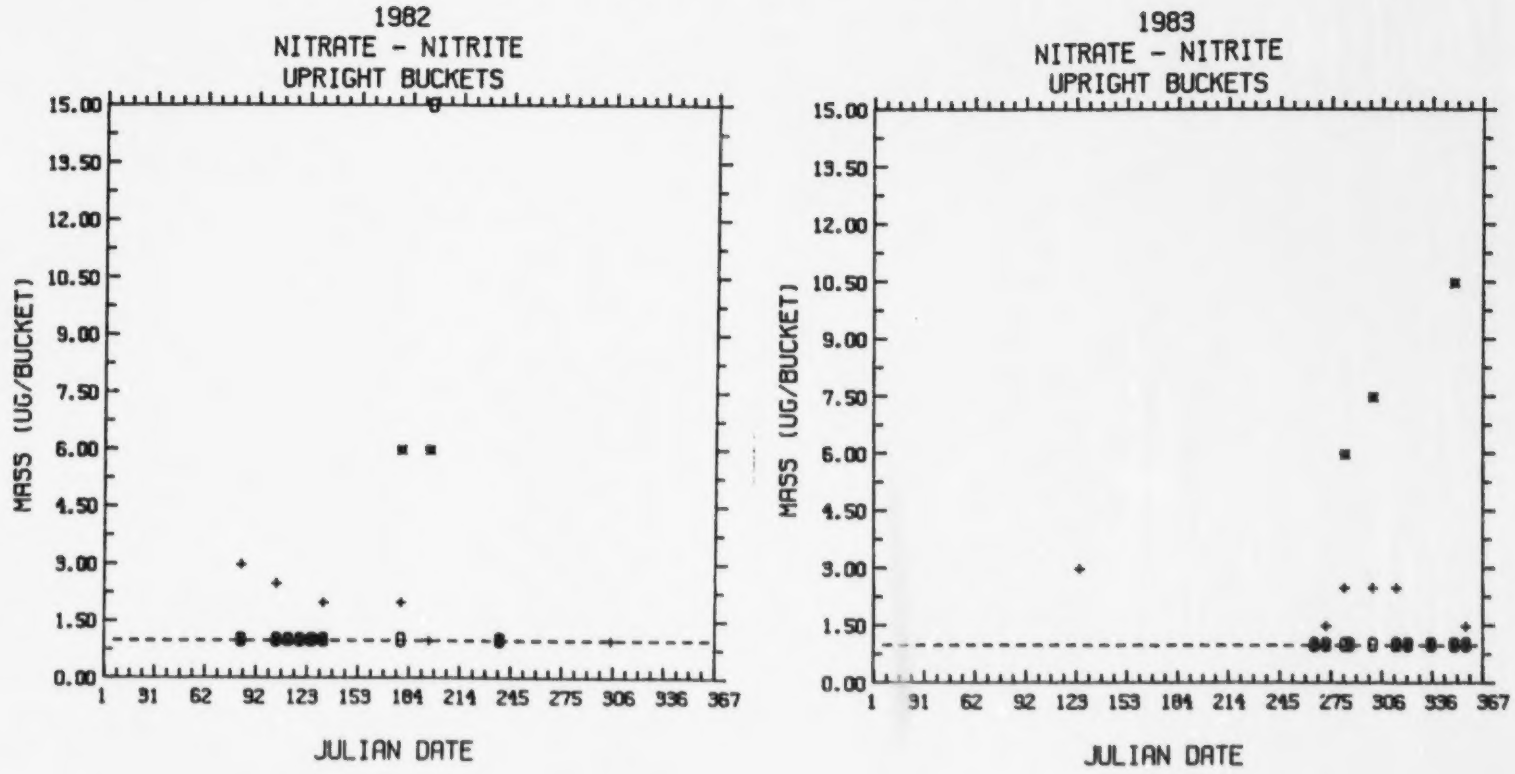


FIGURE 21. Measured nitrate-nitrite concentration in upright bucket blanks for 1982 and 1983.

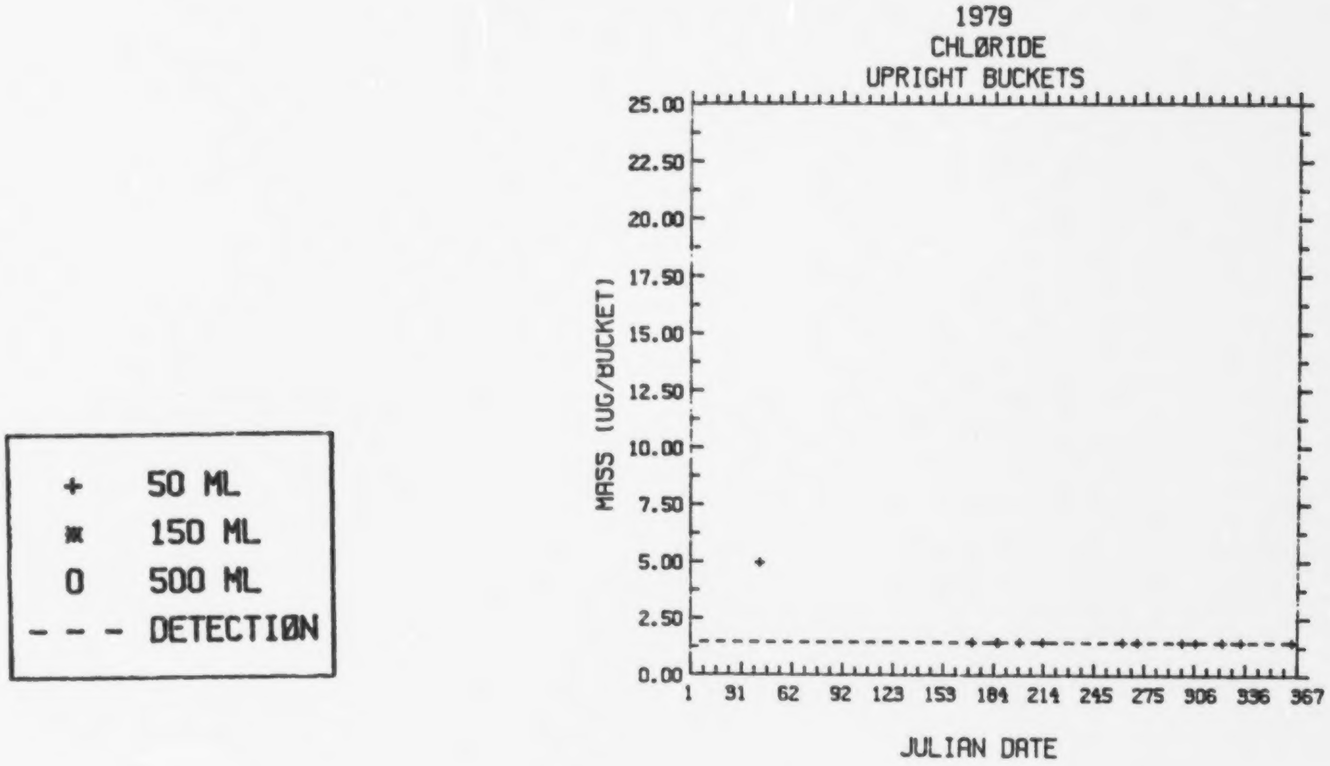


FIGURE 22. Measured chloride mass in upright bucket blanks for 1979.

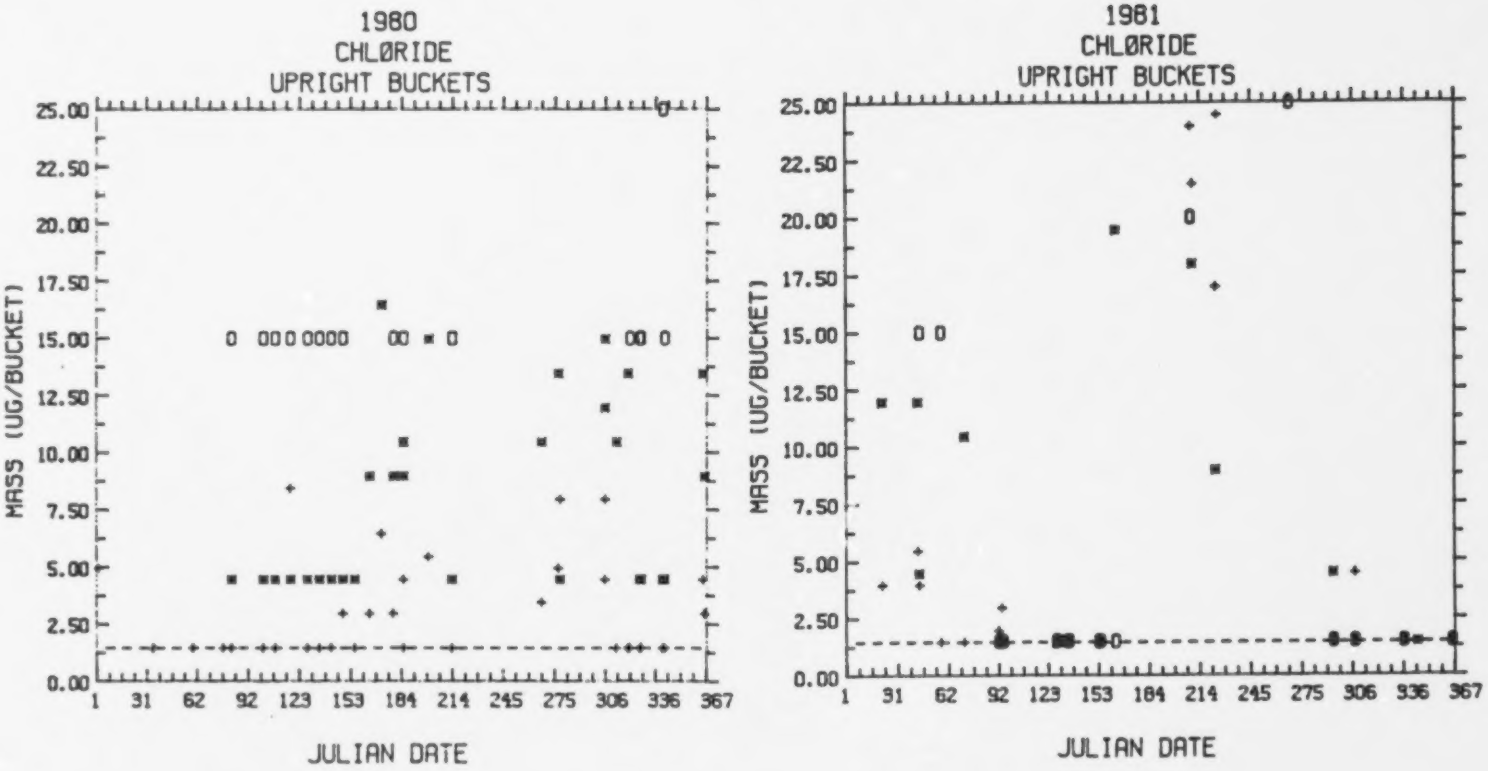


FIGURE 23. Measured chloride mass in upright bucket blanks for 1980 and 1981.

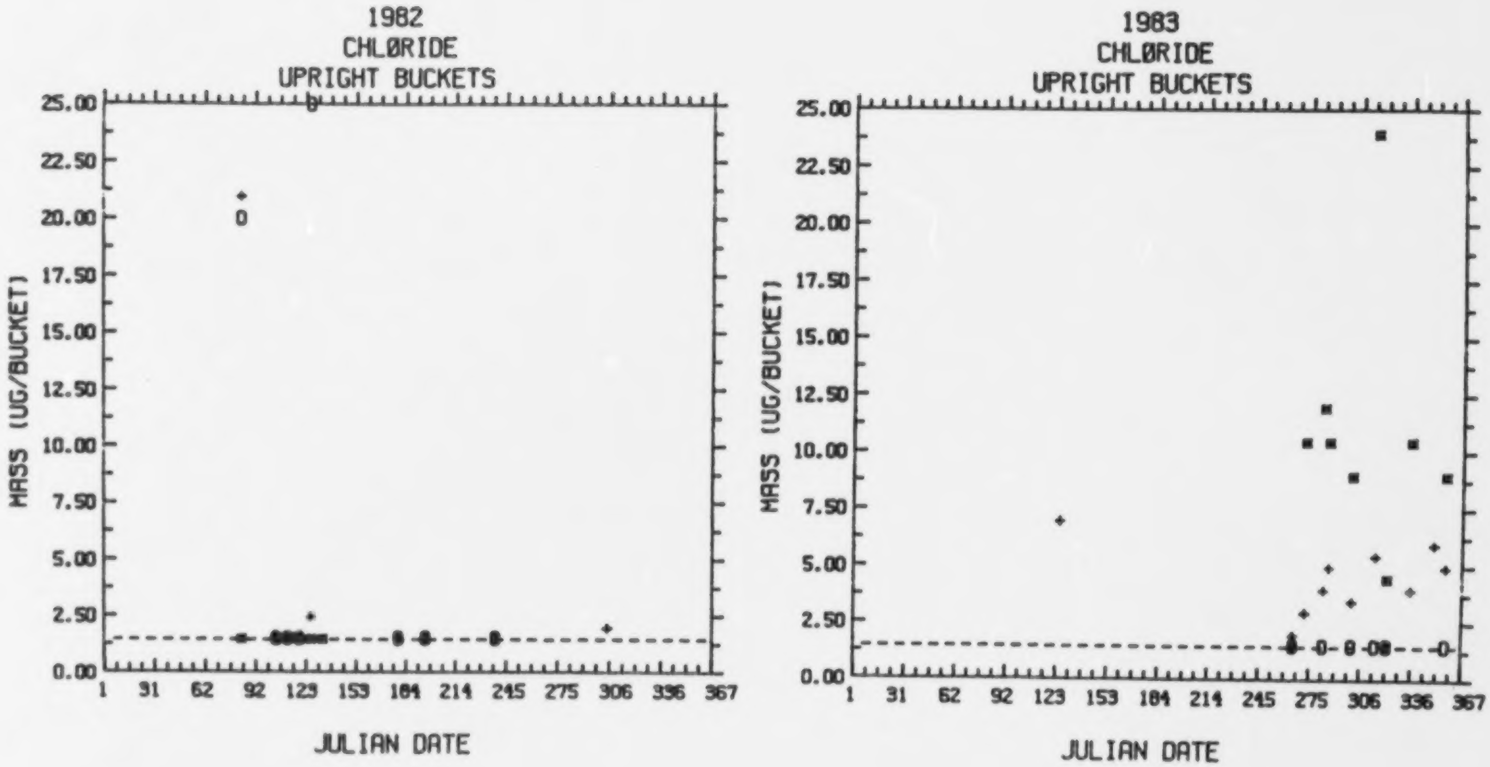


FIGURE 24. Measured chloride mass in upright bucket blanks for 1982 and 1983.

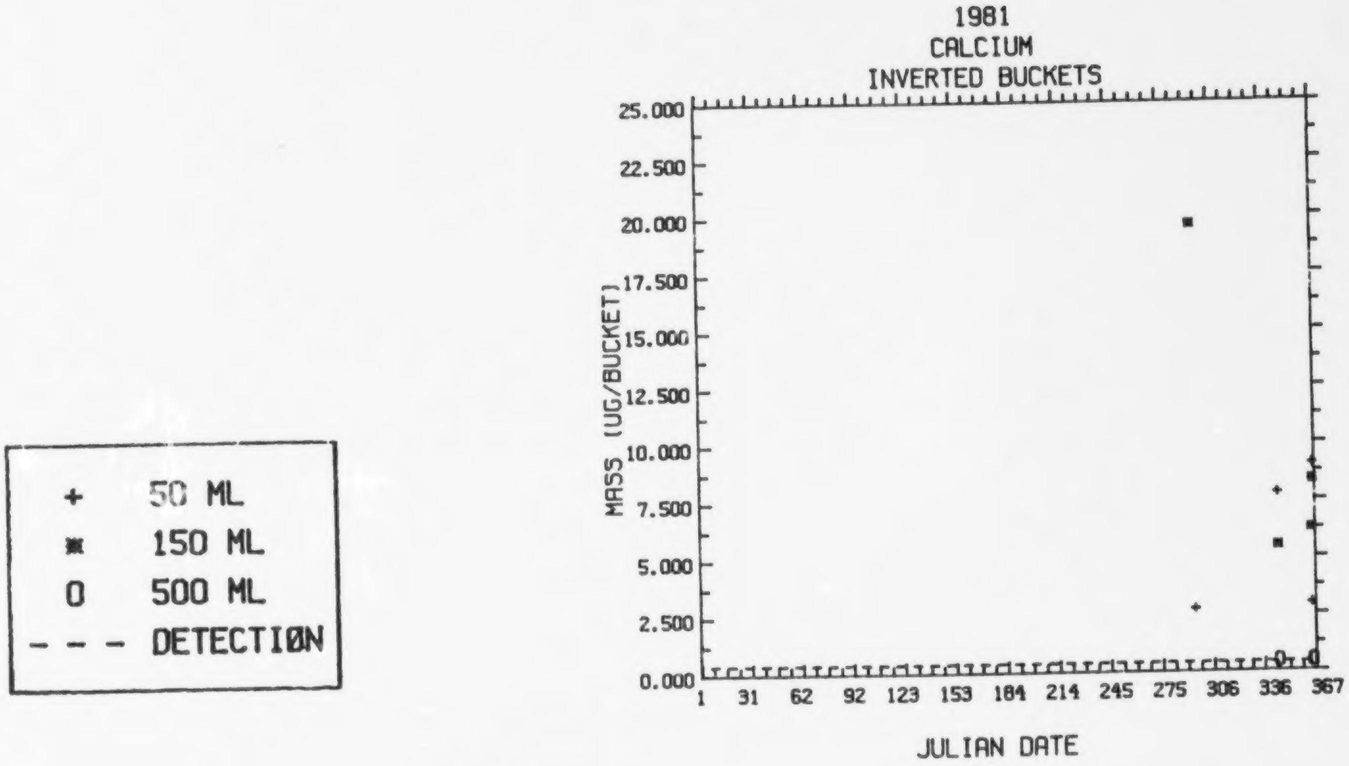


FIGURE 25. Measured calcium mass in inverted bucket blanks for 1981.

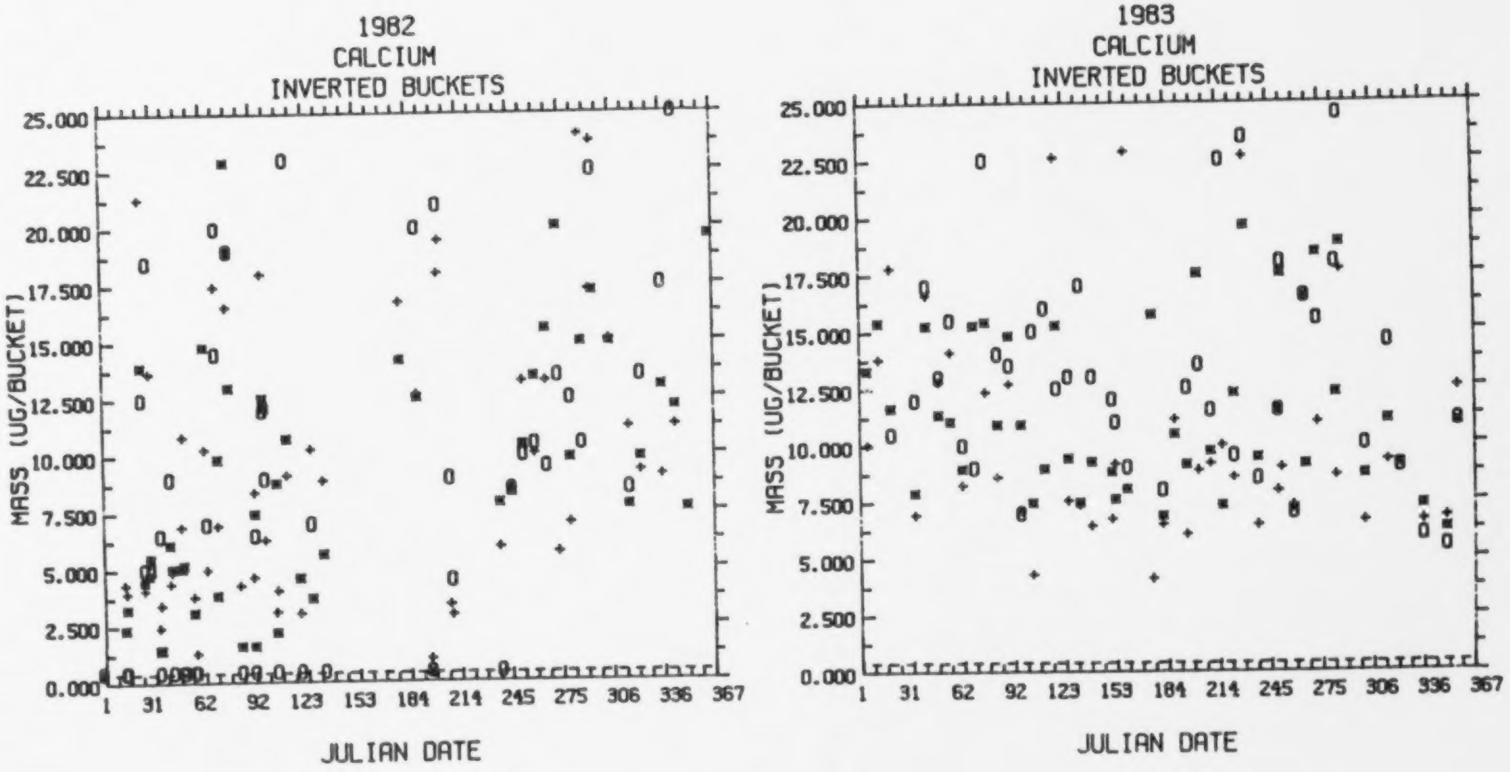


FIGURE 26. Measured calcium mass in inverted bucket blanks for 1982 and 1983.

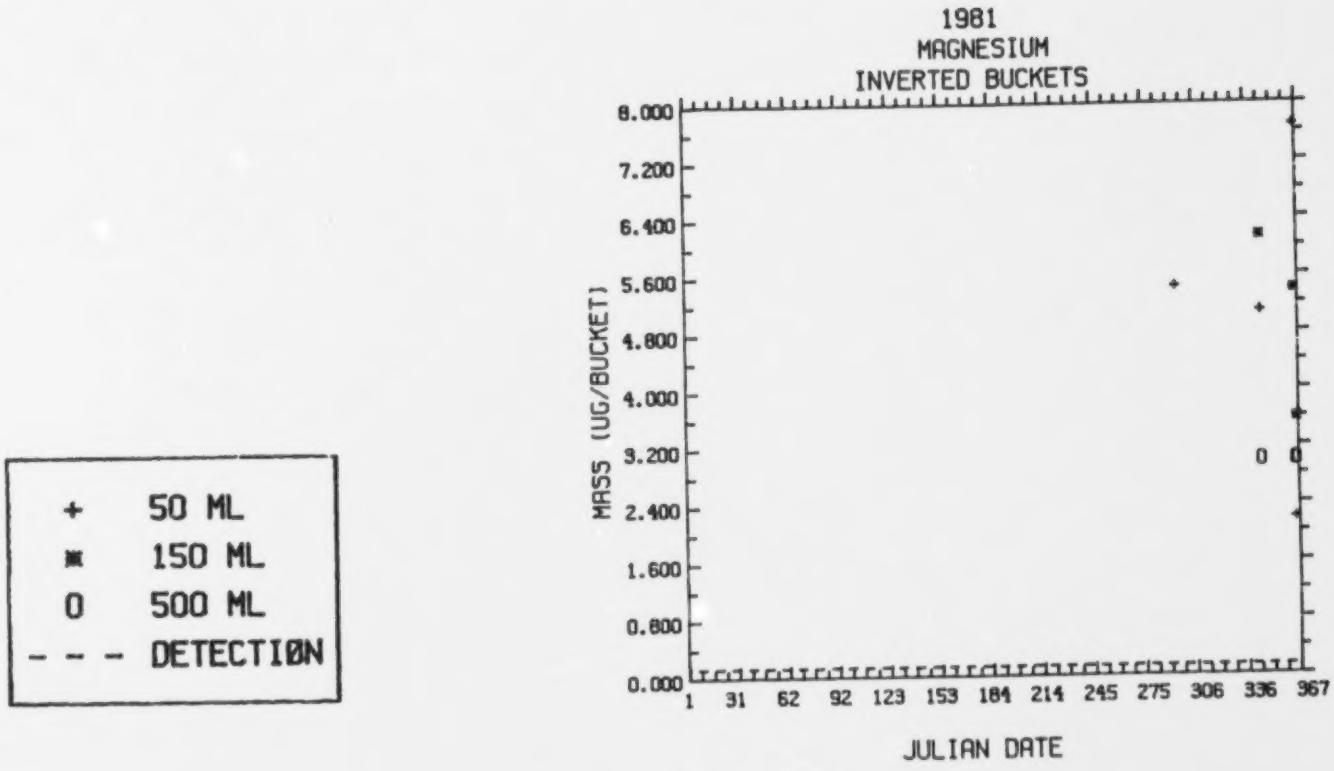


FIGURE 27. Measured magnesium mass in inverted bucket blanks for 1981.

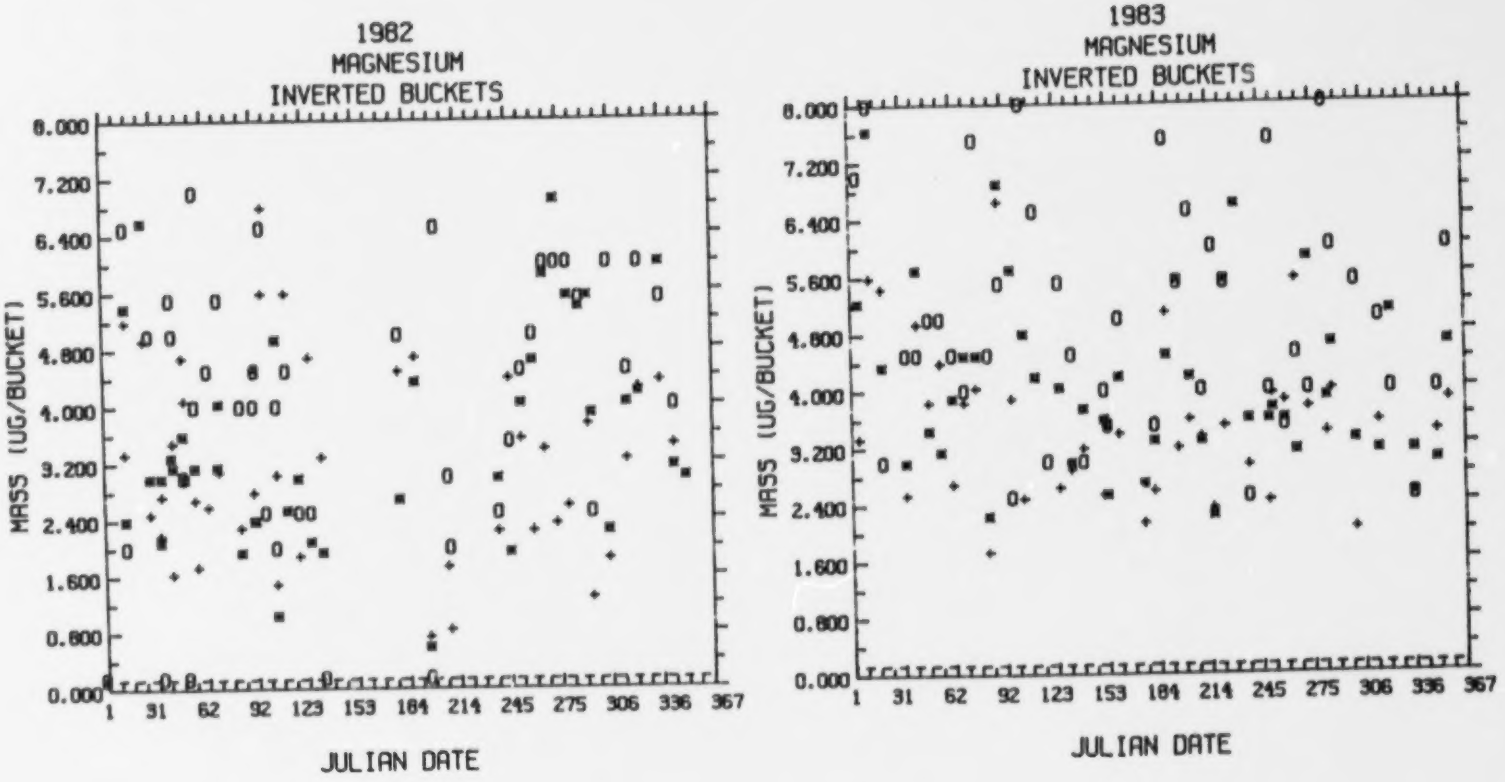


FIGURE 28. Measured magnesium mass in inverted bucket blanks for 1982 and 1983.

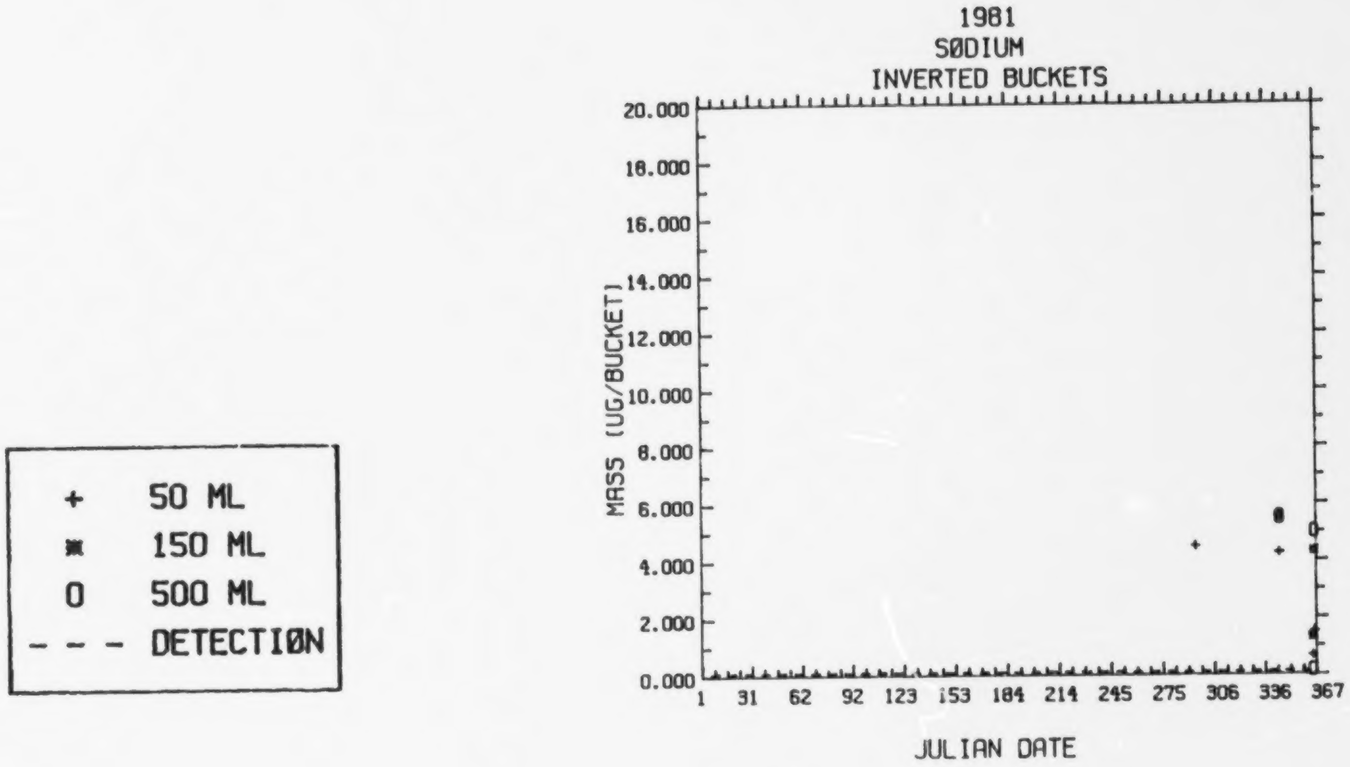


FIGURE 29. Measured sodium mass in inverted bucket blanks for 1981.

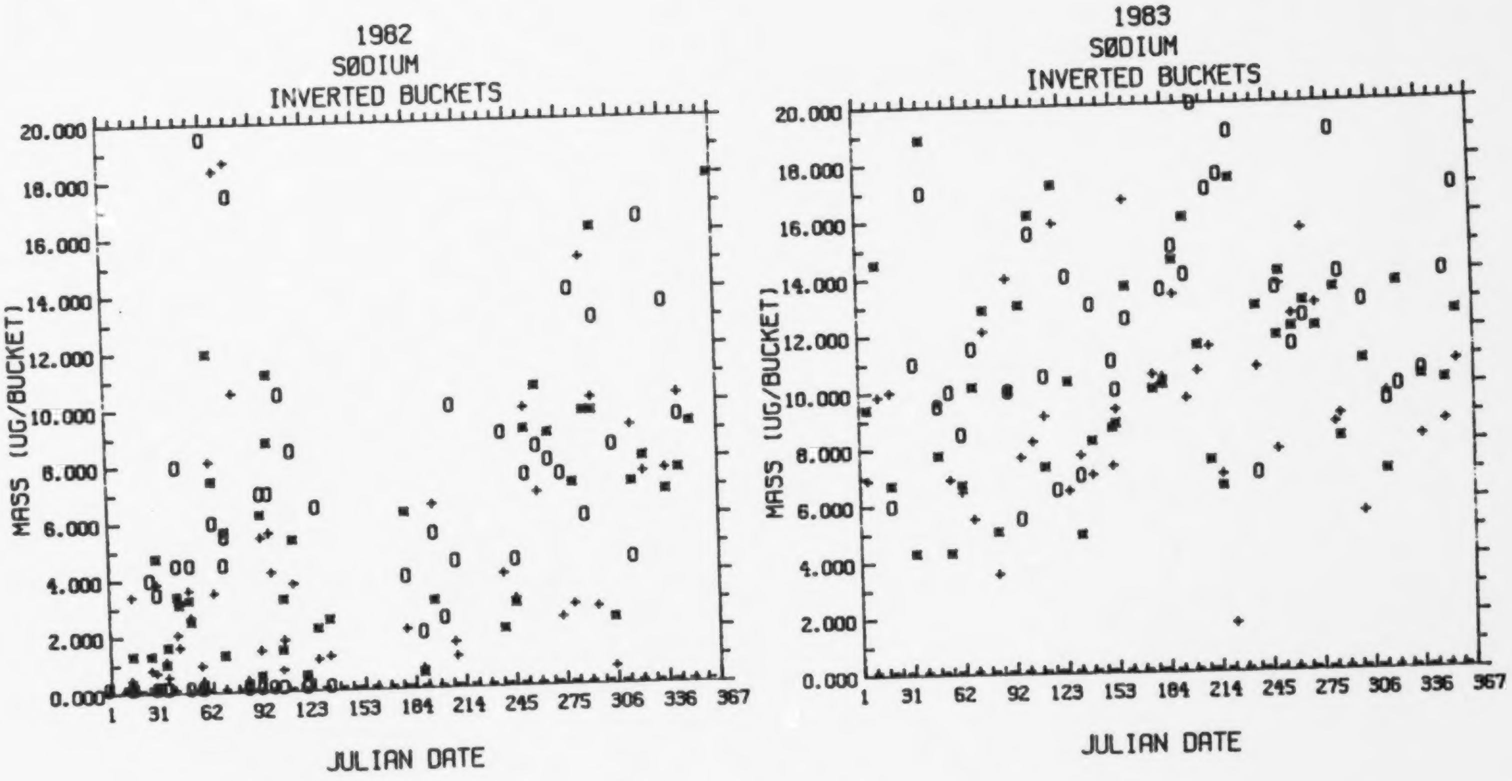


FIGURE 30. Measured sodium mass in inverted bucket blanks for 1982 and 1983.

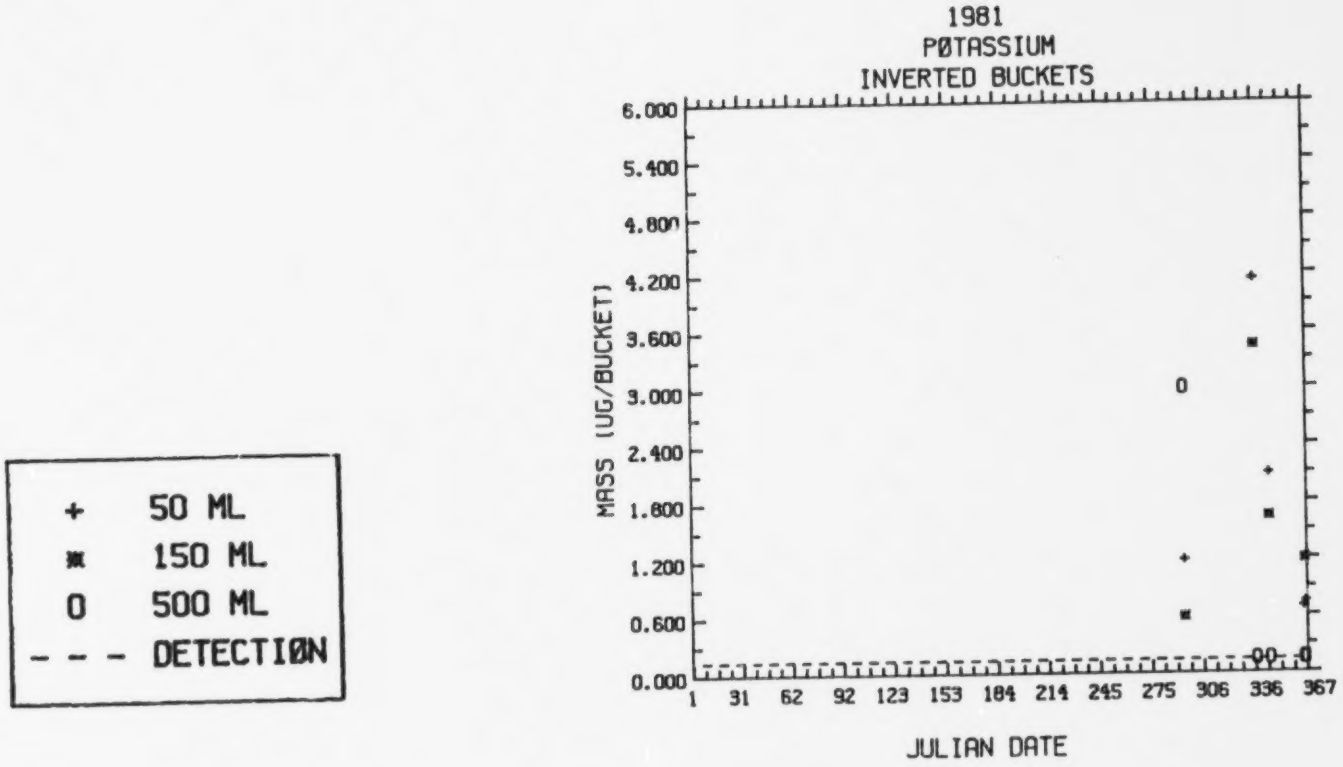


FIGURE 31. Measured potassium mass in inverted bucket blanks for 1981.

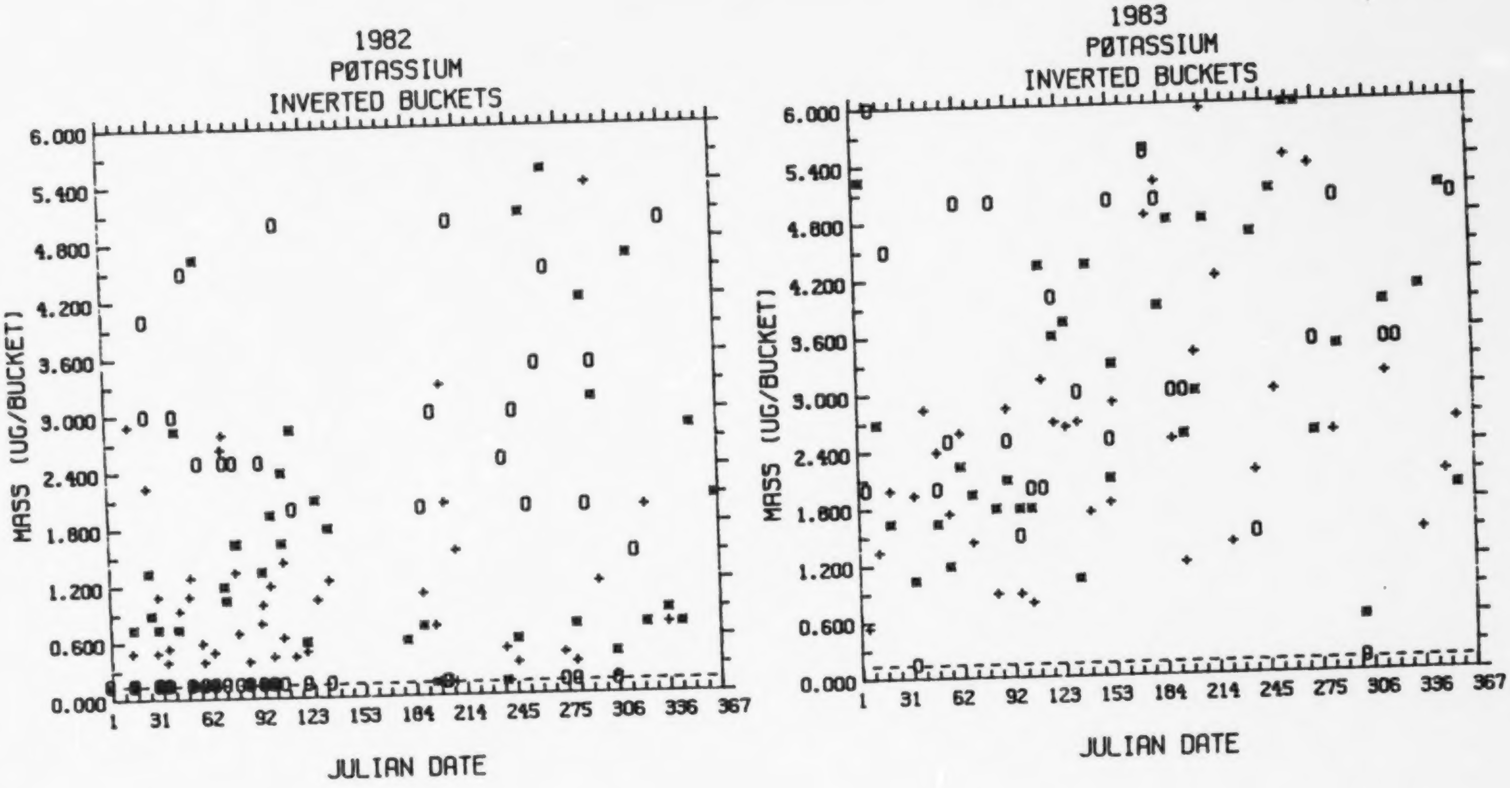


FIGURE 32. Measured potassium mass in inverted bucket blanks for 1982 and 1983.

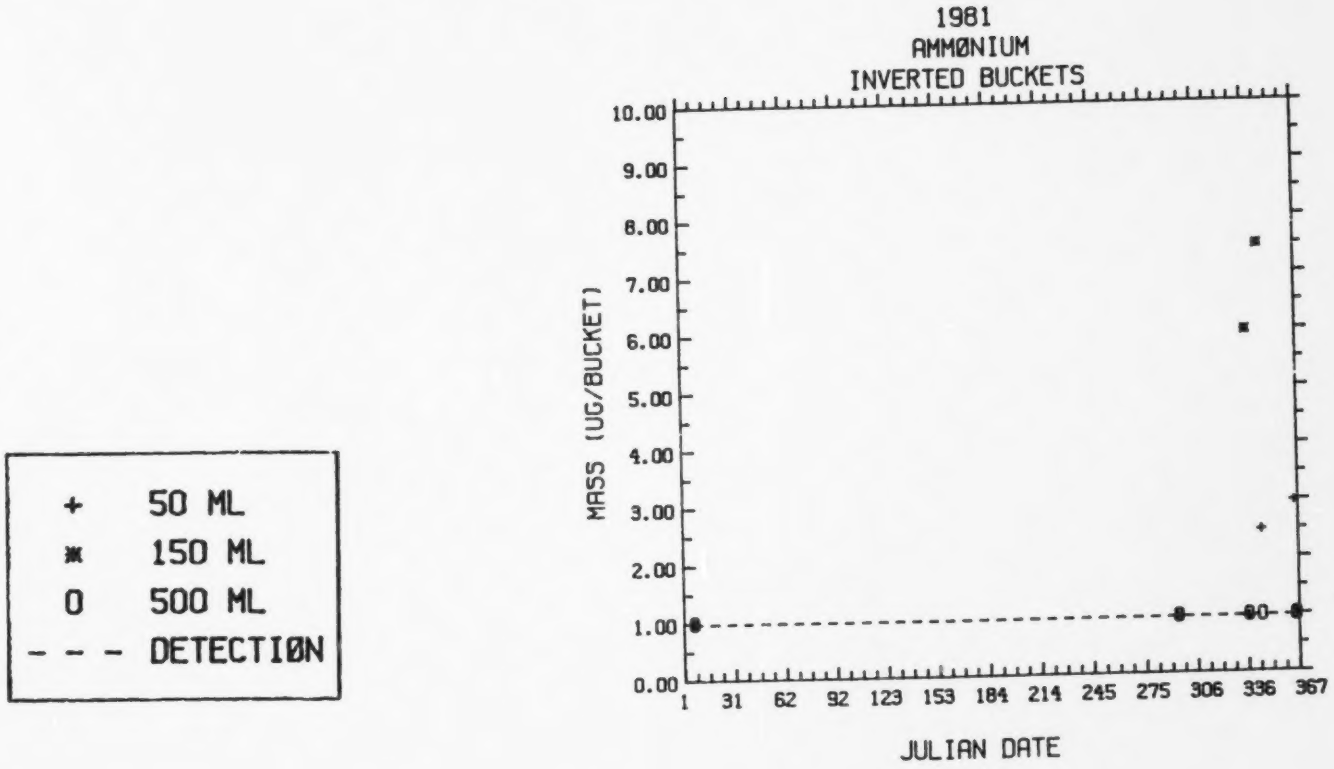


FIGURE 33. **Measured ammonium mass in inverted bucket blanks for 1981.**

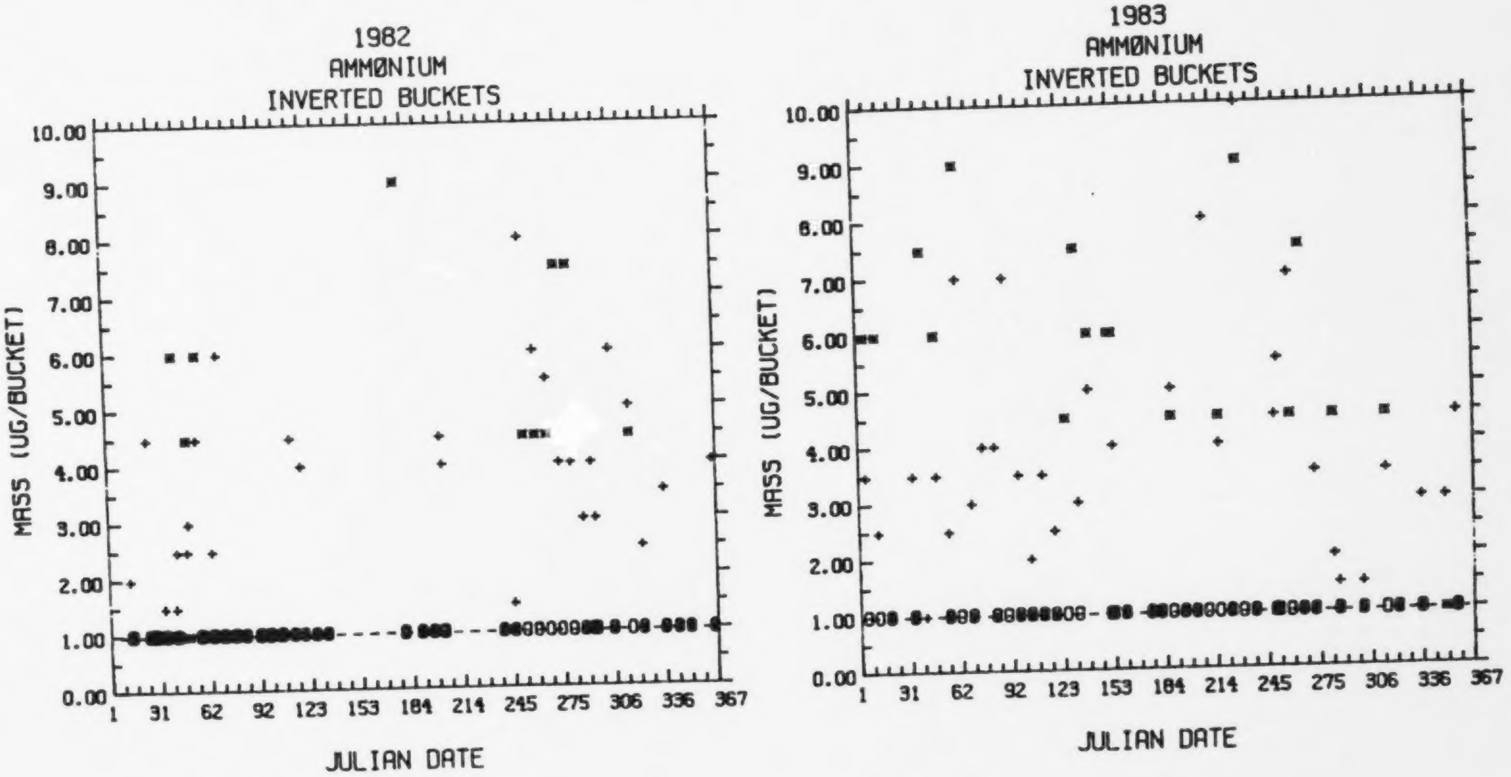


FIGURE 34. Measured ammonium mass in inverted bucket blanks for 1982 and 1983.

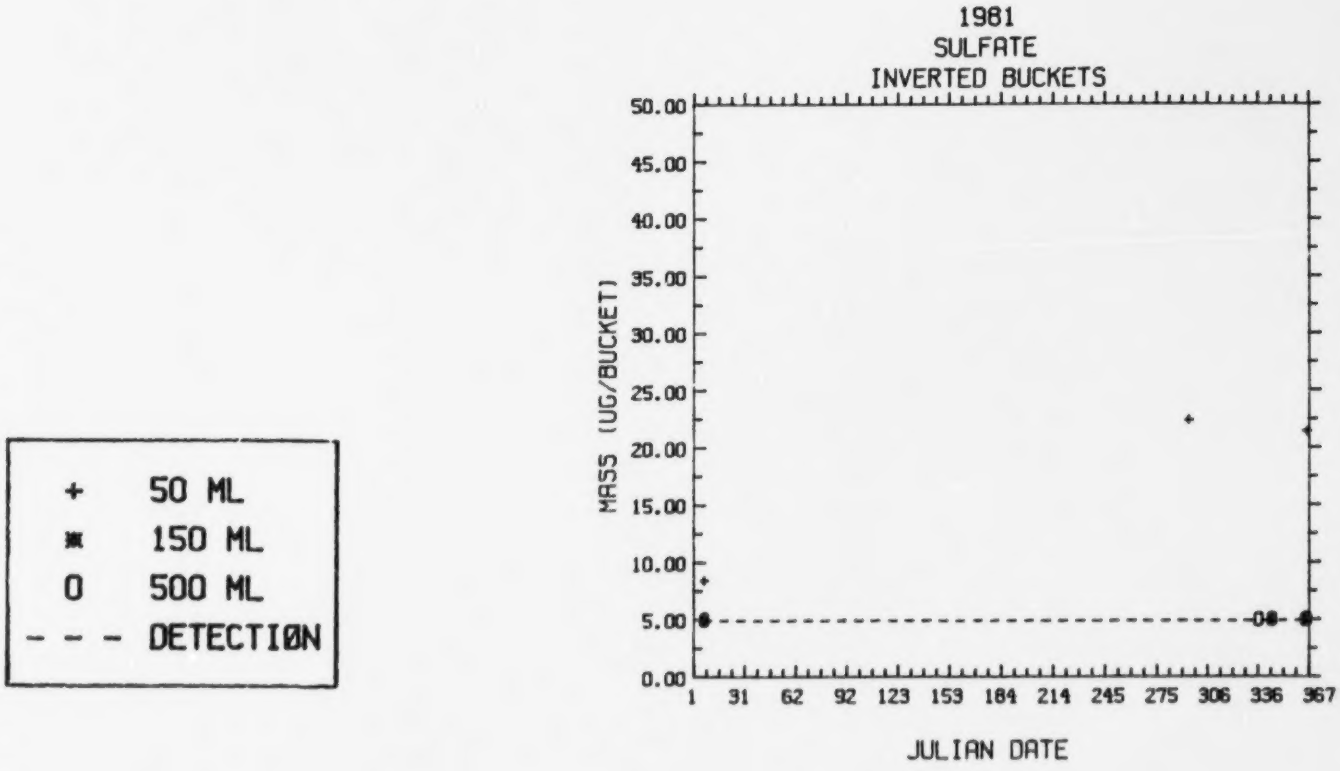


FIGURE 35. Measured sulfate mass in inverted bucket blanks for 1981.

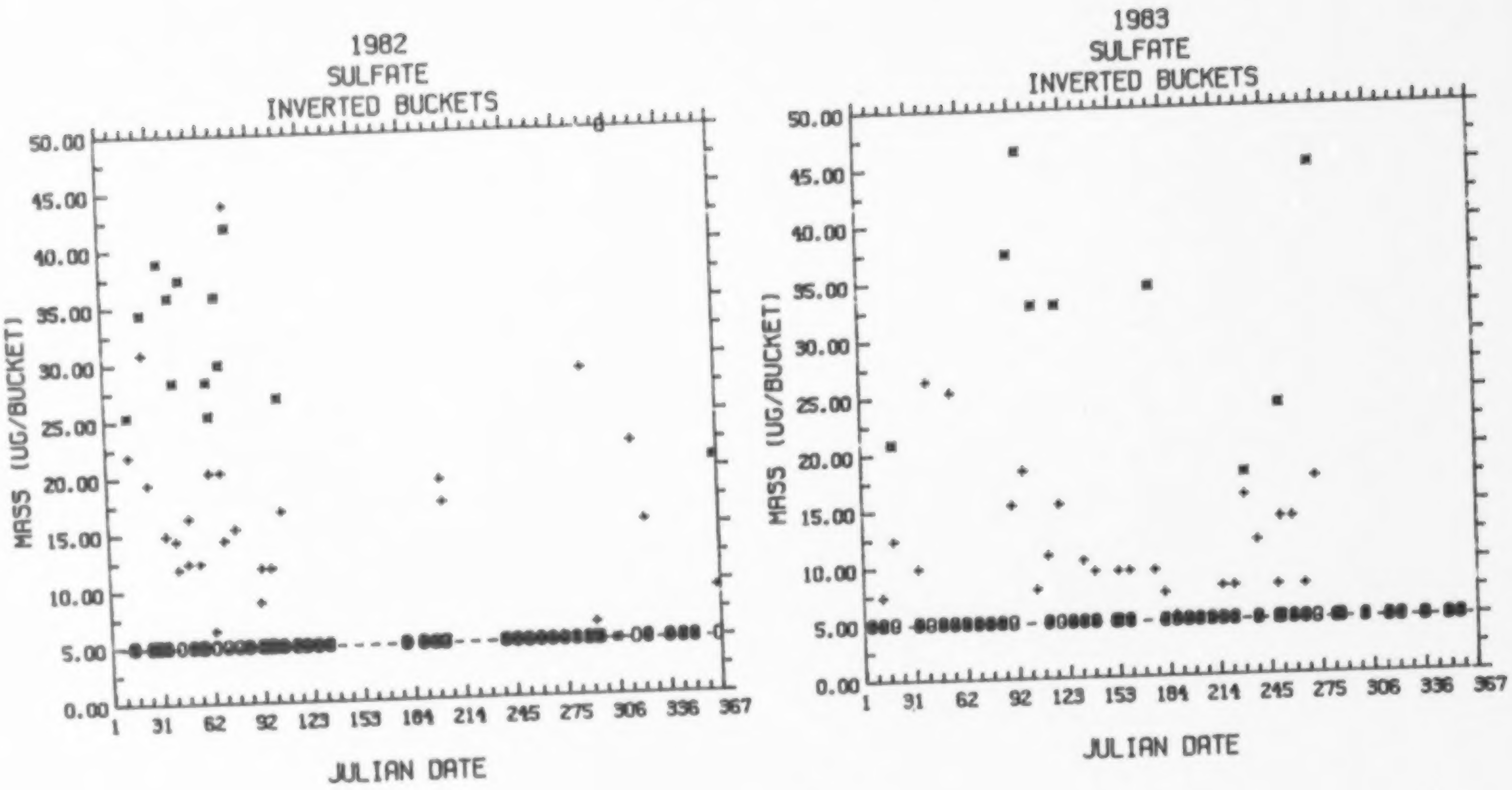


FIGURE 36. Measured sulfate mass in inverted bucket blanks for 1982 and 1983.

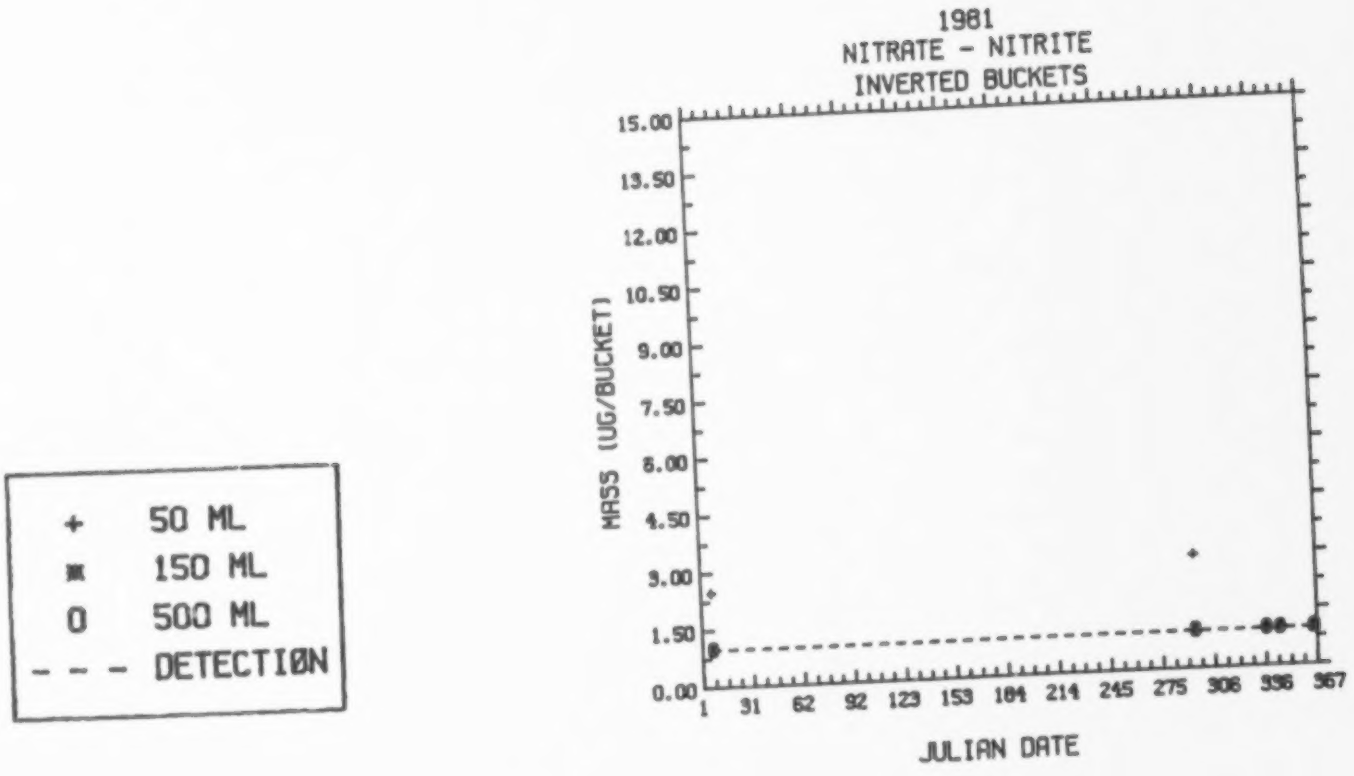


FIGURE 37. Measured nitrate-nitrite mass in inverted bucket blanks for 1981.

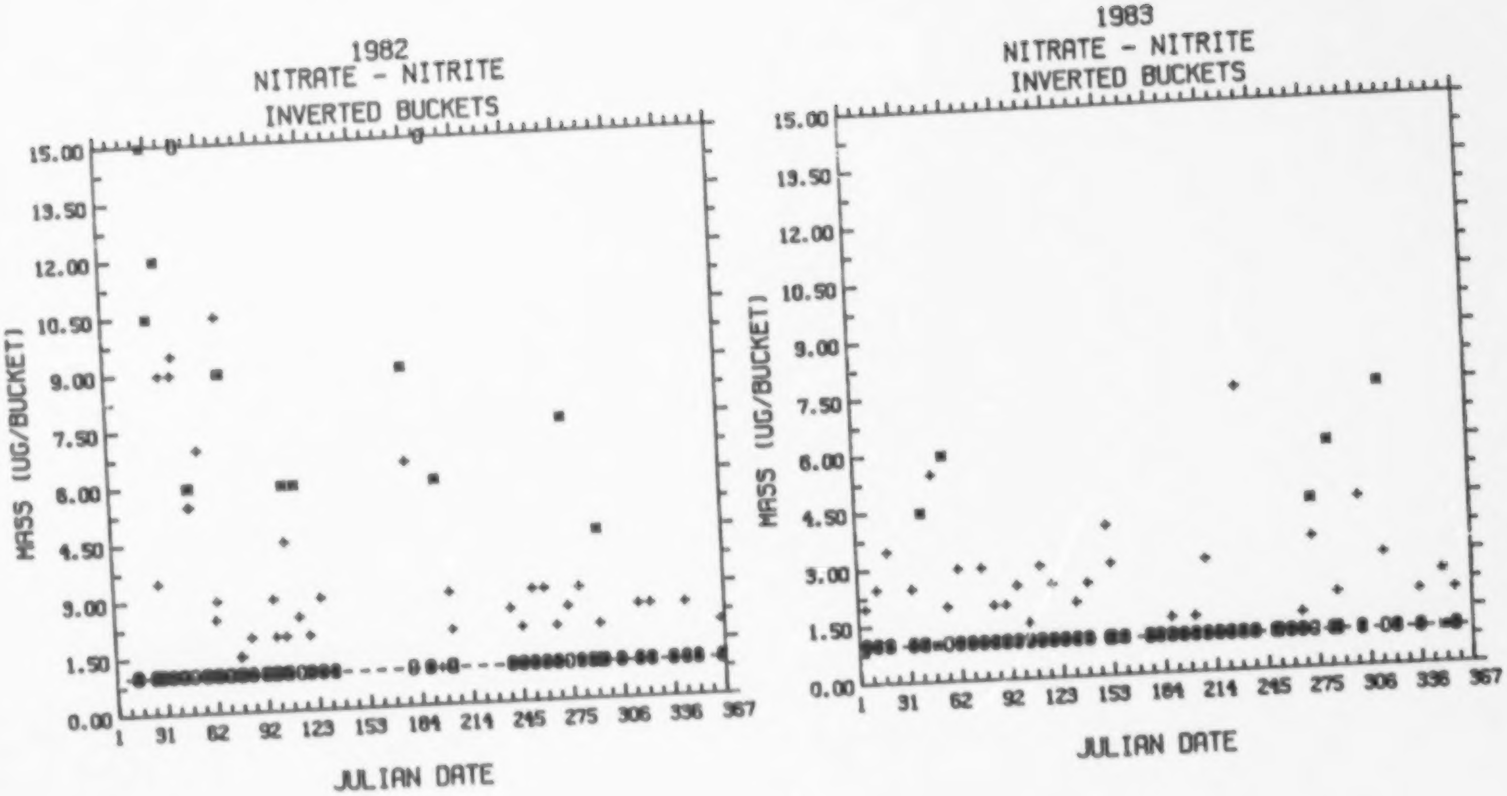


FIGURE 38. Measured nitrate-nitrite mass in inverted bucket blanks for 1982 and 1983.

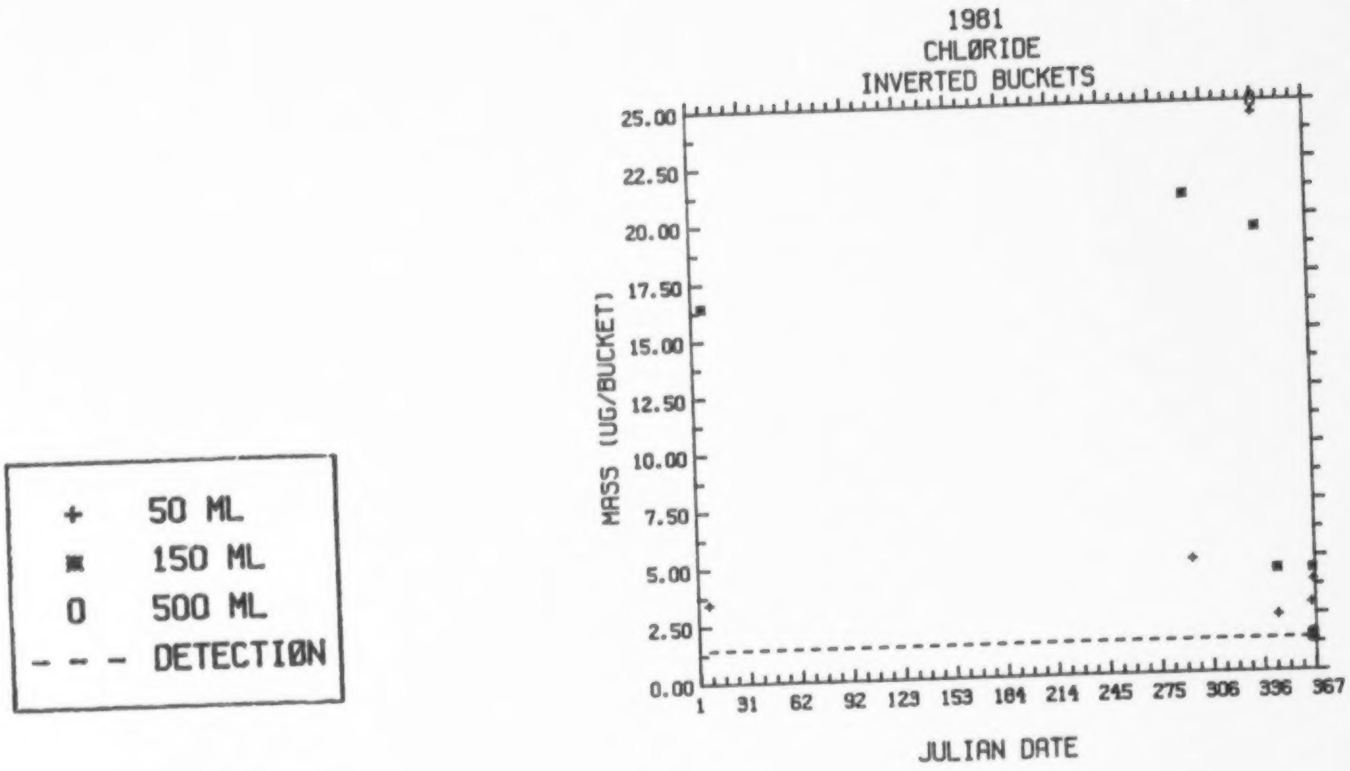


FIGURE 39. Measured chloride mass in inverted bucket blanks for 1981.

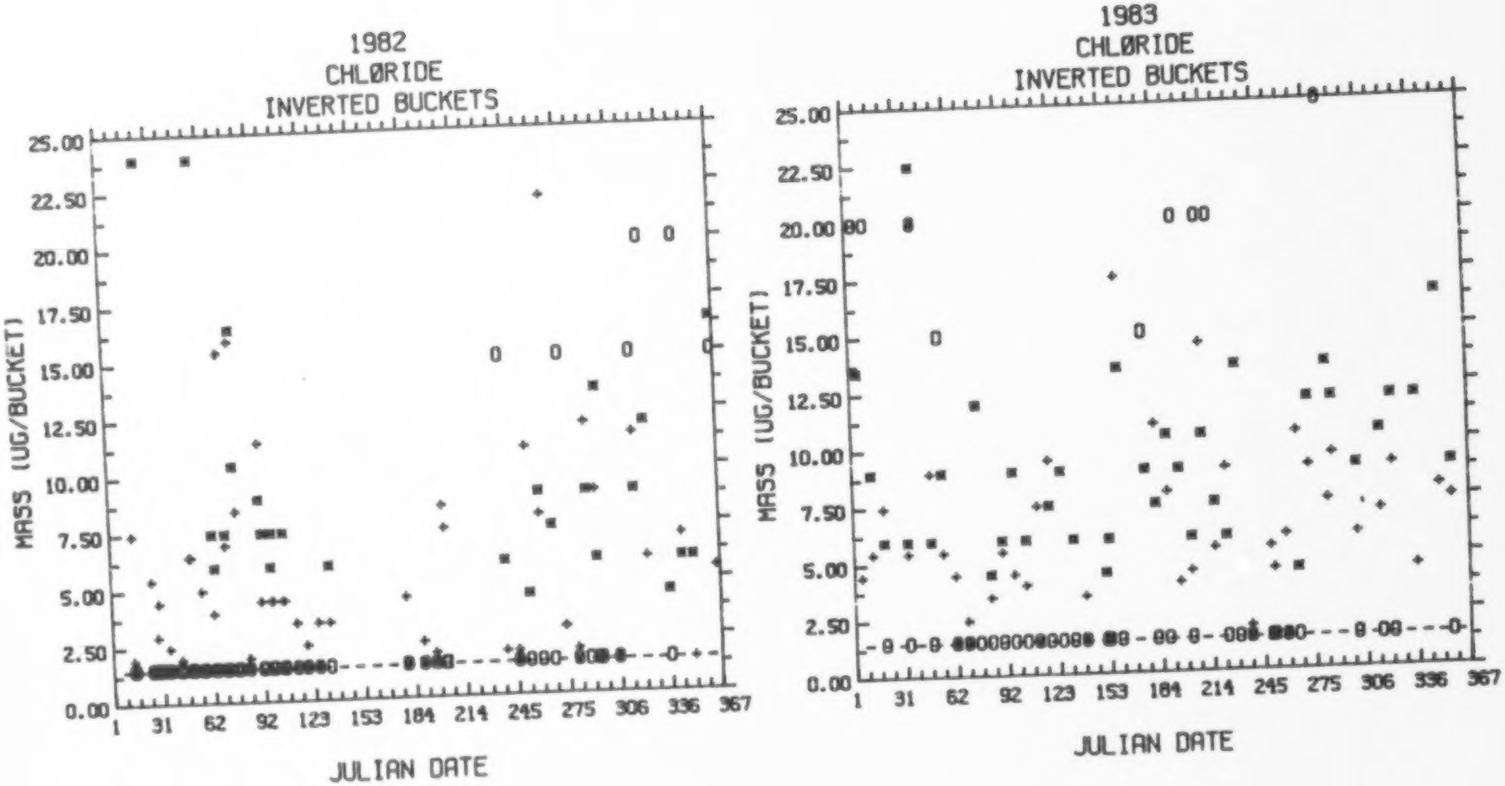


FIGURE 40. Measured chloride mass in inverted bucket blanks for 1982 and 1983.

TABLE 1 Minimum Detectable Mass Values for Bucket Blanks Analyzed from 1978 through 1983.

	Minimum Mass Value (ug/bucket)				
Analyte/Year	**1978-1979**	**1980**	**1981**	**1982**	**1983**
Calcium	1.00	1.00	0.45	0.45	0.45
Magnesium	0.10	0.10	0.15	0.15	0.15
Sodium	0.20	0.20	0.15	0.15	0.15
Potassium	0.20	0.20	0.15	0.15	0.15
Ammonium	1.0	1.0	1.0	1.0	1.0
Sulfate	5.0	5.0	5.0	5.0	5.0
Nitrate-Nitrite	1.0	1.0	1.0	1.0	1.0
Chloride	2.5	2.5	1.0	1.0	1.0
Orthophosphate	0.15	0.15	0.15	0.15	0.15

TABLE 2 Analyte Concentration Summary for Filter Leachate A for 1980.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	69	0.02	98.6	<0.02	<0.02
Magnesium	69	0.002	95.7	<0.002	<0.002
Sodium	69	0.004	69.6	<0.004	0.012
Potassium	69	0.004	94.2	<0.004	<0.004
Ammonium	65	0.02	100.0	<0.02	<0.02
Sulfate	64	0.10	89.1	<0.10	<0.10
Nitrate-Nitrite	65	0.02	83.1	<0.02	0.07
Chloride	65	0.05	70.8	<0.05	0.10
Ortho-phosphate	65	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 3 Analyte Concentration Summary for Filter Leachate A for 1981.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	35	0.009	82.9	<0.009	0.019
Magnesium	35	0.003	65.7	<0.003	0.006
Sodium	35	0.003	8.6	0.008	0.030
Potassium	35	0.003	74.3	<0.003	0.005
Ammonium	35	0.02	97.1	<0.02	<0.02
Sulfate	35	0.10	95.1	<0.10	<0.10
Nitrate-Nitrite	35	0.02	82.9	<0.02	0.04
Chloride	35	0.02	65.9	<0.02	0.06
Ortho-phosphate	35	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 4 Analyte Concentration Summary for Filter Leachate A for 1982.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	41	0.009	97.6	<0.009	<0.009
Magnesium	41	0.003	90.2	<0.003	<0.003
Sodium	41	0.003	17.1	0.008	0.024
Potassium	41	0.003	90.2	<0.003	<0.003
Ammonium	41	0.02	100.0	<0.02	<0.02
Sulfate	41	0.10	95.1	<0.10	<0.10
Nitrate-Nitrite	41	0.02	95.1	<0.02	<0.02
Chloride	41	0.02	65.9	<0.02	0.06
Ortho-phosphate	41	0.003	97.6	<0.003	<0.003

a. number of analyses

TABLE 5 Analyte Concentration Summary for Filter Leachate A for 1983.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	49	0.009	77.6	<0.009	0.017
Magnesium	49	0.003	83.7	<0.003	0.003
Sodium	49	0.003	38.8	0.004	0.016
Potassium	49	0.003	71.4	<0.003	0.008
Ammonium	49	0.02	100.0	<0.02	<0.02
Sulfate	49	0.10	93.9	<0.10	<0.10
Nitrate-Nitrite	49	0.02	100.0	<0.02	<0.02
Chloride	49	0.02	81.6	<0.02	0.06
Ortho-phosphate	49	0.003	98.0	<0.003	<0.003

a. number of analyses

TABLE 6 Analyte Concentration Summary for Filter Leachate B for 1980.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	34	0.02	100.0	<0.02	<0.02
Magnesium	34	0.002	97.1	<0.002	<0.002
Sodium	34	0.004	97.1	<0.004	<0.004
Potassium	34	0.004	100.0	<0.004	<0.004
Ammonium	34	0.02	100.0	<0.02	<0.02
Sulfate	34	0.10	97.1	<0.10	<0.10
Nitrate-Nitrite	34	0.02	100.0	<0.02	<0.02
Chloride	34	0.05	73.5	<0.05	0.07
Ortho-phosphate	34	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 7 Analyte Concentration Summary for Filter Leachate B for 1981.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	34	0.009	94.1	<0.009	<0.009
Magnesium	34	0.003	88.2	<0.003	<0.003
Sodium	34	0.003	70.6	<0.003	0.014
Potassium	34	0.003	88.2	<0.003	<0.003
Ammonium	34	0.02	100.0	<0.02	<0.02
Sulfate	34	0.10	94.1	<0.10	<0.10
Nitrate-Nitrite	34	0.02	85.3	<0.02	0.03
Chloride	34	0.02	55.9	<0.02	0.04
Ortho-phosphate	34	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 8 Analyte Concentration Summary for Filter Leachate B for 1982.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L) 50th	95th
Calcium	41	0.009	97.6	<0.009	<0.009
Magnesium	41	0.003	97.6	<0.003	<0.003
Sodium	41	0.003	85.4	<0.003	0.004
Potassium	41	0.003	95.1	<0.003	<0.003
Ammonium	41	0.02	97.6	<0.02	<0.02
Sulfate	41	0.10	95.1	<0.10	<0.10
Nitrate-Nitrite	41	0.02	97.6	<0.02	<0.02
Chloride	41	0.02	95.1	<0.02	<0.02
Ortho-phosphate	41	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 9 Analyte Concentration Summary for Filter Leachate B for 1983.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L) 50th	95th
Calcium	49	0.009	79.6	<0.009	0.021
Magnesium	49	0.003	85.7	<0.003	0.004
Sodium	49	0.003	79.6	<0.003	0.007
Potassium	49	0.003	75.5	<0.003	0.006
Ammonium	49	0.02	100.0	<0.02	<0.02
Sulfate	49	0.10	93.9	<0.10	<0.10
Nitrate-Nitrite	49	0.02	100.0	<0.02	<0.02
Chloride	49	0.02	91.8	<0.02	<0.02
Ortho-phosphate	49	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 10 Analyte Concentration Summary for Deionized Water Blank for 1980.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	20	0.02	100.0	<0.02	<0.02
Magnesium	20	0.002	95.0	<0.002	<0.002
Sodium	20	0.004	100.0	<0.004	<0.004
Potassium	20	0.004	100.0	<0.004	<0.004
Ammonium	24	0.02	100.0	<0.02	<0.02
Sulfate	24	0.10	95.8	<0.10	<0.10
Nitrate-Nitrite	24	0.02	91.2	<0.02	<0.02
Chloride	24	0.05	70.8	<0.05	0.12
Ortho-phosphate	24	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 11 Analyte Concentration Summary for Deionized Water Blank for 1981.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L)	
				50th	95th
Calcium	33	0.009	93.9	<0.009	<0.009
Magnesium	33	0.003	97.0	<0.003	<0.003
Sodium	33	0.003	90.9	<0.003	<0.003
Potassium	33	0.003	97.0	<0.003	<0.003
Ammonium	34	0.02	97.1	<0.02	<0.02
Sulfate	34	0.10	88.2	<0.10	<0.10
Nitrate-Nitrite	34	0.02	100.0	<0.02	<0.02
Chloride	34	0.02	61.8	<0.02	0.04
Ortho-phosphate	34	0.003	97.1	<0.003	<0.003

a. number of analyses

TABLE 12 Analyte Concentration Summary for Deionized Water Blank for 1982.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L) 50th	95th
Calcium	40	0.009	100.0	<0.009	<0.009
Magnesium	40	0.003	97.5	<0.003	<0.003
Sodium	40	0.003	90.0	<0.003	<0.003
Potassium	40	0.003	97.5	<0.003	<0.003
Ammonium	39	0.02	100.0	<0.02	<0.02
Sulfate	39	0.10	94.9	<0.10	<0.10
Nitrate-Nitrite	39	0.02	97.4	<0.02	<0.02
Chloride	39	0.02	100.0	<0.02	<0.02
Ortho-phosphate	39	0.003	100.0	<0.003	<0.003

a. number of analyses

TABLE 13 Analyte Concentration Summary for Deionized Water Blank for 1983.

Analyte	n[a]	Detection Limit (mg/L)	Frequency of MDL (%)	Percentile (mg/L) 50th	95th
Calcium	48	0.009	100.0	<0.009	<0.009
Magnesium	48	0.003	100.0	<0.003	<0.003
Sodium	48	0.003	93.8	<0.003	<0.003
Potassium	48	0.003	97.9	<0.003	<0.003
Ammonium	48	0.02	97.9	<0.02	<0.02
Sulfate	48	0.10	100.0	<0.10	<0.10
Nitrate-Nitrite	48	0.02	100.0	<0.02	<0.02
Chloride	48	0.02	95.8	<0.02	<0.02
Ortho-phosphate	48	0.003	95.8	<0.003	<0.003

a. number of analyses

APPENDIX B

Tables of Annual Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation

1978-1983

TABLE 1 Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation - 1978.

	Percentile Concentration Values (mg/L)									
Parameter	Min.	5th	10th	25th	50th	75th	90th	95th	99th	Max.
Ca	<0.02	0.02	0.04	0.07	0.14	0.32	0.67	1.13	2.15	3.3
Mg	<0.002	0.008	0.010	0.019	0.037	0.081	0.209	0.254	0.631	1.3
K	<0.004	0.005	0.010	0.020	0.033	0.060	0.130	0.196	0.334	3.8
Na	0.009	0.028	0.051	0.090	0.222	0.565	1.52	2.33	7.24	23.1
NH_4	<0.02	<0.02	<0.02	0.04	0.16	0.38	0.74	1.27	2.28	3.0
NO_3	<0.02	0.22	0.32	0.60	1.30	2.25	3.36	4.82	10.41	15.3
Cl	<0.05	0.07	0.10	0.13	0.23	0.51	1.55	2.78	6.75	16.0
SO_4	<0.10	0.57	0.78	1.30	2.30	3.96	6.61	10.32	15.71	22.8
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	0.013	0.048	0.3
pH (units)	3.50	3.75	3.97	4.19	4.43	4.93	5.48	6.12	6.58	7.0
Specific Conductance (uS/cm)	3.4	6.4	7.6	11.7	20.5	31.2	54.5	88.9	141.0	175.5

Source: National Atmospheric Deposition Program (NADP)
1978 - wet side samples (w)
Number of samples (N) = 239

TABLE 2 Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation - 1979.

	Percentile Concentration Values (mg/L)									
Parameter	Min.	5th	10th	25th	50th	75th	90th	95th	99th	Max.
Ca	<0.02	0.03	0.05	0.09	0.19	0.42	0.93	1.45	2.35	6.8
Mg	<0.002	0.010	0.013	0.022	0.041	0.086	0.168	0.223	0.505	1.5
K	<0.004	0.005	0.008	0.015	0.030	0.060	0.124	0.223	0.569	35.2
Na	0.009	0.037	0.050	0.100	0.248	0.620	1.40	2.52	7.10	23.5
NH_4	<0.02	<0.02	<0.02	0.07	0.22	0.50	0.90	1.35	2.55	134.0
NO_3	<0.02	0.25	0.38	0.76	1.40	2.49	3.83	5.30	8.90	16.3
Cl	<0.05	<0.05	0.07	0.10	0.20	0.40	0.85	1.40	2.69	53.0
SO_4	<0.10	0.60	0.85	1.45	2.60	4.30	6.67	8.70	13.57	40.4
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.007	0.419	21.8
pH (units)	3.57	3.93	4.04	4.26	4.55	5.07	6.01	6.44	7.01	8.2
Specific Conductance (uS/cm)	2.1	6.1	8.1	12.2	21.1	34.3	51.0	65.7	101.9	644.0

Source: National Atmospheric Deposition Program (NADP)
1979 - wet side samples (w)
Number of samples (N) = 1254

TABLE 3 Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation - 1980.

	Percentile Concentration Values (mg/L)									
Parameter	Min.	5th	10th	25th	50th	75th	90th	95th	99th	Max.
Ca	<0.02	0.03	0.05	0.09	0.19	0.43	0.93	1.57	5.22	16.4
Mg	<0.002	0.008	0.012	0.022	0.042	0.093	0.200	0.338	0.966	4.9
K	<0.004	0.004	0.008	0.015	0.030	0.065	0.159	0.306	1.14	29.9
Na	<0.004	0.016	0.025	0.054	0.130	0.351	0.981	1.99	5.55	29.3
NH_4	<0.02	<0.02	<0.02	0.07	0.22	0.50	0.94	1.42	3.24	47.0
NO_3	<0.02	0.11	0.23	0.72	1.49	2.63	4.12	5.16	9.16	54.1
Cl	<0.05	0.10	0.12	0.18	0.27	0.48	1.02	1.96	6.75	23.1
SO_4	<0.10	0.36	0.57	1.13	2.20	3.74	5.92	7.75	15.56	56.2
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.008	0.903	15.9
pH (units)	3.16	3.89	4.02	4.25	4.56	5.36	6.07	6.49	7.16	7.9
Specific Conductance (uS/cm)	1.9	5.4	7.5	12.4	22.2	35.7	53.5	68.5	115.7	427.1

Source: National Atmospheric Deposition Program (NADP)
1980 - wet side samples (w)
Number of samples (N) = 3030

TABLE 4 Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation - 1981.

	Percentile Concentration Values (mg/L)									
Parameter	Min.	5th	10th	25th	50th	75th	90th	95th	99th	Max.
Ca	<0.02	0.04	0.05	0.10	0.22	0.48	1.08	1.82	4.40	16.7
Mg	0.009	0.013	0.019	0.033	0.062	0.137	0.325	0.557	1.120	8.5
K	<0.003	0.006	0.009	0.016	0.031	0.066	0.142	0.255	0.863	17.3
Na	<0.003	0.022	0.032	0.058	0.122	0.313	0.779	1.39	4.43	65.0
NH_4	<0.02	<0.02	<0.02	0.08	0.23	0.44	0.81	1.19	2.40	78.2
NO_3	<0.02	0.10	0.21	0.60	1.25	2.15	3.31	4.53	8.10	27.3
Cl	<0.02	0.04	0.05	0.10	0.21	0.47	1.12	1.94	6.88	121.9
SO_4	<0.10	0.39	0.54	1.08	2.19	3.82	5.78	7.57	14.65	31.8
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.013	0.248	16.8
pH (units)	3.34	3.96	4.06	4.29	4.67	5.46	6.11	6.44	6.92	8.5
Specific Conductance (uS/cm)	1.5	5.3	6.9	11.9	22.0	35.1	54.1	69.0	113.5	538.2

Source: National Atmospheric Deposition Program (NADP)
1981 - wet side samples (w)
Number of samples (N) = 3370

TABLE 5 Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation - 1982.

Parameter	Min.	5th	10th	25th	50th	75th	90th	95th	99th	Max.
	Percentile Concentration Values (mg/L)									
Ca	<0.01	0.02	0.04	0.07	0.16	0.35	0.71	1.08	2.51	27.3
Mg	<0.003	0.009	0.013	0.023	0.044	0.091	0.176	0.287	0.775	6.5
K	<0.003	0.006	0.008	0.015	0.027	0.052	0.105	0.170	0.475	3.3
Na	<0.003	0.018	0.023	0.043	0.092	0.216	0.546	1.08	3.29	46.7
NH_4	<0.02	<0.02	<0.02	0.08	0.19	0.39	0.68	0.95	1.93	6.6
NO_3	<0.02	0.12	0.24	0.58	1.11	1.94	3.23	4.32	7.90	43.2
Cl	<0.02	0.04	0.05	0.09	0.17	0.38	0.92	1.72	5.59	78.1
SO_4	<0.10	0.30	0.45	0.85	1.65	2.99	4.89	6.26	11.21	34.3
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.025	1.5
pH (units)	3.19	3.99	4.10	4.35	4.74	5.33	5.81	6.12	6.58	7.6
Specific Conductance (uS/cm)	1.8	4.1	5.7	9.3	17.2	29.8	47.8	62.8	101.0	402.5

Source: National Atmospheric Deposition Program (NADP)
1982 - wet side samples (w)
Number of samples (N) = 3590

TABLE 6 Percentile Concentration Values of Chemical and Physical Parameters Measured in Precipitation - 1983.

Parameter	Min.	5th	10th	25th	50th	75th	90th	95th	99th	Max.
	Percentile Concentration Values (mg/L)									
Ca	<0.01	0.03	0.04	0.07	0.16	0.36	0.73	1.15	2.54	18.9
Mg	<0.003	0.010	0.013	0.021	0.040	0.082	0.165	0.259	0.599	4.4
K	<0.003	0.007	0.009	0.016	0.031	0.060	0.123	0.192	0.534	3.9
Na	0.007	0.022	0.029	0.048	0.102	0.238	0.592	1.09	3.25	36.0
NH_4	<0.02	<0.02	<0.02	0.06	0.17	0.40	0.71	1.04	1.93	7.7
NO_3	<0.02	0.12	0.23	0.51	1.02	1.86	3.09	4.21	7.26	28.4
Cl	<0.02	0.05	0.07	0.10	0.17	0.36	0.93	1.73	5.92	64.9
SO_4	<0.10	0.32	0.46	0.78	1.38	2.59	4.41	5.92	10.93	21.4
PO_4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	0.021	3.1
pH (units)	3.15	3.99	4.15	4.42	4.81	5.37	5.86	6.12	6.56	7.4
Specific Conductance (uS/cm)	1.5	3.6	4.8	8.3	14.8	26.0	43.0	58.6	110.4	431.4

Source: National Atmospheric Deposition Program (NADP)/
National Trends Network (NTN)
1983 - wet side samples (w)
Number of samples (N) = 4308

APPENDIX C
Tables of Analytical Bias and Precision Determined from Analysis of Quality Control Check Samples
1978-1983

TABLE 1 Selected pH Values and the Corresponding Hydrogen Ion Content Expressed as Microequivalents per Liter.

pH (units)	Hydrogen Ion (uequivalents/L)
3.50	316.2
4.00	100.0
4.30	50.1
4.50	31.6
4.70	20.0
5.00	10.0
5.30	5.0
5.50	3.2
5.70	2.0

TABLE 2 pH Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, pH units (uequivalents/L)	Measured Concentration, pH units (uequivalents/L)	n^a	Bias[b]		Precision[b]	
				units	%	s units	RSD %
1979	3.06 (871.0)	3.16 (691.8)	14	0.10	-20.7	0.05	10.9
	4.08 (83.2)	4.26 (55.0)	12	0.18	-33.9	0.22	39.8
1980	4.06 (87.1)	4.01 (98.2)	14	-0.05	12.7	0.07	16.1
	4.25 (56.2)	4.27 (54.3)	11	0.02	- 3.4	0.03	7.0
1981	4.30 (50.1)	4.30 (50.1)	158	0.00	0.0	0.04	8.8
	5.63 (2.3)	5.60 (2.5)	57	-0.03	8.7	0.12	24.0
1982	4.30 (50.1)	4.32 (48.3)	467	0.02	-3.6	0.02	4.3
	5.63 (2.3)	5.45 (3.5)	452	-0.18	52.2	0.05	11.1
1983	4.30 (50.1)	4.31 (49.0)	444	0.01	-2.2	0.03	6.7
	5.63 (2.3)	5.43 (3.7)	444	-0.20	60.9	0.08	18.9

a. number of replicates

b. calculations of bias and precision were made using hydrogen ion concentration

TABLE 3 Specific Conductance Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, uS/cm	Measured Concentration, uS/cm	n[a]	Bias uS/cm	Bias %	Precision s uS/cm	Precision RSD %
1979	35.5	35.9	9	0.4	1.1	1.7	4.7
	401	403.4	14	2.4	0.6	4.6	1.1
1980	25.0	23.7	4	-1.3	-5.2	1.3	5.5
	36.4	41.8	10	5.4	14.8	4.5	10.8
1981	21.8	22.7	105	0.9	4.1	2.9	12.8
1982	21.8	22.1	448	0.3	1.4	0.9	4.1
1983	21.8	21.5	443	-0.3	-1.4	0.7	3.3

a. number of replicates

TABLE 4 Calcium Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	0.35	0.37	9	0.02	5.7	0.01	2.7	YES
	0.53	0.55	6	0.02	3.8	0.01	1.8	YES
	1.45	1.49	24	0.04	2.8	0.02	1.3	YES
1980	0.53	0.53	131	0.00	0.0	0.02	3.8	NO
	0.81	0.82	131	0.01	1.2	0.01	1.2	NO
	1.45	1.51	13	0.06	4.1	0.02	1.3	YES
1981	0.067	0.058	59	-0.009	-13.4	0.004	6.9	YES
	0.317	0.314	59	-0.003	-1.0	0.005	1.6	NO
	0.530	0.530	138	0.000	0.0	0.008	1.5	NO
	0.812	0.811	138	-0.001	-0.1	0.010	1.2	NO
1982	0.067	0.062	302	-0.005	-7.5	0.004	6.5	YES
	0.317	0.315	302	-0.002	-0.6	0.005	1.6	NO
1983	0.053	0.052	35	-0.001	-1.9	0.003	5.8	NO
	0.067	0.066	434	-0.001	-1.5	0.003	4.6	NO
	0.317	0.323	429	0.006	1.9	0.004	1.2	YES
	0.402	0.412	35	0.010	2.5	0.003	0.7	YES

a. number of replicates
b. 95% confidence level

TABLE 5 Magnesium Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	0.114	0.116	9	0.002	1.8	0.002	1.7	NO
	0.171	0.173	6	0.002	1.2	0.002	1.2	NO
	0.300	0.299	24	-0.001	-0.3	0.003	1.0	NO
1980	0.168	0.174	129	0.006	3.6	0.002	1.2	YES
	0.180	0.186	141	0.006	3.3	0.002	1.1	YES
	0.300	0.299	14	-0.001	-0.3	0.002	0.7	NO
1981	0.024	0.021	59	-0.003	-12.5	0.001	4.8	YES
	0.070	0.069	59	-0.001	-1.4	0.001	1.4	NO
	0.168	0.171	138	0.003	1.8	0.002	1.2	YES
	0.180	0.184	138	0.004	2.2	0.003	1.6	YES
1982	0.024	0.022	302	-0.002	-8.3	0.001	4.5	YES
	0.070	0.070	302	0.000	0.0	0.001	1.4	NO
1983	0.018	0.018	35	0.000	0.0	0.001	5.6	NO
	0.024	0.023	444	-0.001	-4.2	0.001	4.3	YES
	0.070	0.070	435	0.000	0.0	0.001	1.4	NO
	0.083	0.083	35	0.000	0.0	0.001	1.2	NO

a. number of replicates
b. 95% confidence level

TABLE 6 Sodium Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	0.157	0.158	5	0.001	0.6	0.001	0.6	NO
	0.314	0.313	6	-0.001	-0.3	0.008	2.6	NO
	0.472	0.471	5	-0.001	-0.2	0.006	1.3	NO
	0.500	0.499	25	-0.001	-0.2	0.004	0.8	NO
1980	0.500	0.497	13	-0.003	-0.6	0.004	0.8	NO
	0.820	0.818	149	-0.002	-0.2	0.004	0.5	NO
	0.932	0.926	149	-0.006	-0.6	0.006	0.6	NO
1981	0.071	0.068	60	-0.003	-4.2	0.002	2.9	YES
	0.395	0.381	60	-0.014	-3.5	0.003	0.8	YES
	0.820	0.818	121	-0.002	-0.2	0.005	0.6	NO
	0.932	0.919	121	-0.013	-1.4	0.007	0.8	NO
1982	0.071	0.068	310	-0.003	-4.2	0.002	2.9	YES
	0.395	0.392	310	-0.003	-0.8	0.008	2.0	NO
1983	0.071	0.070	425	-0.001	-1.4	0.002	2.9	NO
	0.083	0.084	17	0.001	1.2	0.002	2.4	NO
	0.395	0.399	417	0.004	1.0	0.005	1.3	NO
	0.459	0.472	17	0.013	2.8	0.003	0.6	YES

a. number of replicates
b. 95% confidence level

TABLE 7 Potassium Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	0.033	0.031	5	-0.002	-6.1	0.002	6.5	YES
	0.067	0.066	6	-0.001	-1.5	0.002	3.0	NO
	0.100	0.101	3	0.001	1.0	0.001	1.0	NO
	0.270	0.271	29	0.001	0.4	0.004	1.5	NO
1980	0.196	0.190	149	-0.006	-3.1	0.003	1.6	YES
	0.210	0.210	146	0.000	0.0	0.002	1.0	NO
	0.270	0.268	13	-0.002	-0.7	0.005	1.9	NO
1981	0.014	0.014	60	0.000	0.0	0.002	14.3	NO
	0.056	0.058	60	0.002	3.6	0.004	6.9	YES
	0.196	0.188	121	-0.008	-4.1	0.003	1.6	YES
	0.210	0.210	121	0.000	0.0	0.002	1.0	NO
1982	0.014	0.014	156	0.000	0.0	0.001	7.1	NO
	0.017	0.017	154	0.000	0.0	0.001	5.9	NO
	0.056	0.057	156	0.001	1.8	0.002	3.5	NO
	0.074	0.071	154	-0.003	-4.1	0.002	2.8	YES
1983	0.017	0.017	425	0.000	0.0	0.001	5.9	NO
	0.021	0.020	17	-0.001	-4.8	0.001	5.0	YES
	0.074	0.071	427	-0.003	-4.1	0.001	1.4	YES
	0.100	0.092	17	-0.008	-8.0	0.002	2.2	YES

a. number of replicates
b. 95% confidence level

TABLE 8 Ammonium Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	0.30	0.30	24	0.00	0.0	0.02	6.7	NO
	2.05	2.05	23	0.00	0.0	0.03	1.5	NO
1980	0.24	0.24	23	0.00	0.0	0.01	4.2	NO
	0.30	0.29	76	-0.01	-3.3	0.02	6.9	YES
	1.67	1.67	26	0.00	0.0	0.05	3.0	NO
	2.05	2.03	84	-0.02	-1.0	0.05	2.5	YES
1981	0.24	0.23	178	-0.01	-4.2	0.02	8.7	YES
	0.84	0.83	90	-0.01	-1.2	0.03	3.6	YES
	1.67	1.66	90	-0.01	-0.6	0.04	2.4	NO
1982	0.19	0.21	116	0.02	10.5	0.02	9.5	YES
	0.24	0.24	133	0.00	0.0	0.02	8.3	NO
	0.84	0.80	149	-0.04	-4.8	0.03	3.8	YES
	0.98	0.96	121	-0.02	-2.0	0.11	11.5	NO
1983	0.19	0.21	231	0.02	10.5	0.02	9.5	YES
	0.36	0.37	116	0.01	2.8	0.02	5.4	YES
	0.98	1.01	200	0.03	3.1	0.04	4.0	YES
	1.22	1.23	116	0.01	0.8	0.03	2.4	NO

a. number of replicates
b. 95% confidence level

TABLE 9 Sulfate Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias		Precision		Statistically Significant Bias?[b]
				mg/L	%	s mg/L	RSD %	
1979	1.20	1.20	31	0.00	0.0	0.02	1.6	NO
	5.12	5.14	24	0.02	0.4	0.04	0.8	NO
	10.24	10.22	18	-0.02	-0.2	0.06	0.6	NO
1980	0.72	0.72	116	0.00	0.0	0.05	6.9	NO
	9.36	9.33	182	-0.03	-0.3	0.25	2.7	NO
1981	0.36	0.36	74	0.00	0.0	0.02	5.6	NO
	1.17	1.19	61	0.02	1.7	0.06	5.0	NO
	1.87	1.90	92	0.03	1.6	0.08	4.2	YES
	7.35	7.33	172	-0.02	-0.3	0.21	2.9	NO
	9.36	9.42	140	0.06	0.6	0.21	2.2	NO
1982	1.17	1.15	216	-0.02	-1.7	0.11	9.6	NO
	7.35	7.31	262	-0.04	-0.5	0.27	3.7	NO
1983	0.92	0.86	285	-0.06	-6.5	0.12	14.0	YES
	1.17	1.10	76	-0.07	-6.0	0.11	10.0	YES
	6.86	7.05	261	0.19	2.8	0.39	5.5	NO
	7.35	7.29	69	-0.06	-0.8	0.27	3.7	NO

a. number of replicates
b. 95% confidence level

TABLE 10 Nitrate-Nitrite Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias		Precision		Statistically Significant Bias?[b]
				mg/L	%	s mg/L	RSD %	
1979	0.49	0.50	38	0.01	2.0	0.01	2.0	YES
	1.68	1.67	40	-0.01	-0.6	0.03	1.8	NO
1980	0.49	0.48	111	-0.01	-2.0	0.03	6.3	YES
	1.37	1.41	24	0.04	2.9	0.03	2.2	YES
	1.68	1.72	111	0.04	2.4	0.07	4.2	YES
	3.52	3.60	17	0.08	2.3	0.08	2.2	NO
	7.04	7.12	8	0.08	1.1	0.20	2.8	NO
1981	1.37	1.38	201	0.01	0.7	0.07	5.1	NO
	3.52	3.51	205	-0.01	-0.3	0.12	3.4	NO
1982	0.80	0.77	121	-0.03	-3.8	0.01	1.3	YES
	1.37	1.31	142	-0.06	-4.4	0.05	3.8	YES
	3.54	3.38	226	-0.16	-4.5	0.14	4.1	YES
1983	0.62	0.63	117	0.01	1.6	0.02	3.2	NO
	0.80	0.80	119	0.00	0.0	0.03	3.8	NO
	3.14	3.15	118	0.01	0.3	0.05	1.6	NO
	3.54	3.57	191	0.03	0.9	0.06	1.7	YES

a. number of replicates
b. 95% confidence level

TABLE 11 Chloride Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	1.41	1.47	3	0.06	4.3	0.01	0.7	YES
	2.81	2.93	16	0.12	4.3	0.03	1.0	YES
	4.32	4.53	16	0.21	4.9	0.03	0.7	YES
1980	0.36	0.37	80	0.01	2.8	0.03	8.1	YES
	0.92	0.88	19	-0.04	-4.4	0.02	2.3	YES
	1.84	1.82	101	-0.02	-1.1	0.06	3.3	YES
	4.40	4.42	17	0.02	0.5	0.07	1.6	NO
	8.79	8.91	12	0.12	1.4	0.08	0.9	YES
1981	0.71	0.71	78	0.00	0.0	0.04	5.6	NO
	0.92	0.91	137	-0.01	-1.1	0.04	4.4	YES
	1.84	1.74	45	-0.10	-5.4	0.04	2.3	YES
	2.08	2.09	80	0.01	0.5	0.07	3.3	NO
1982	0.71	0.71	262	0.00	0.0	0.03	4.2	NO
	2.08	2.00	243	-0.08	-3.9	0.07	3.5	YES
1983	0.71	0.70	100	-0.01	-1.4	0.03	4.3	YES
	0.86	0.86	220	0.00	0.0	0.04	4.7	NO
	1.80	1.83	217	0.03	1.7	0.07	3.8	YES
	2.08	2.03	91	-0.05	-2.4	0.09	4.4	YES

a. number of replicates
b. 95% confidence level

TABLE 12 Orthophosphate Measurements - Bias and Precision Determined from Analysis of Quality Control Check Samples.

Year	Theoretical Concentration, mg/L	Measured Concentration, mg/L	n[a]	Bias mg/L	Bias %	Precision s mg/L	Precision RSD %	Statistically Significant Bias?[b]
1979	0.058	0.058	16	0.000	0.0	0.001	1.7	NO
	0.080	0.079	17	-0.001	-1.3	0.002	2.5	NO
1980	0.016	0.016	54	0.000	0.0	0.001	6.3	NO
	0.095	0.095	53	0.000	0.0	0.004	4.0	NO
	0.236	0.234	16	-0.002	-0.9	0.003	1.3	YES
	0.583	0.568	9	-0.015	-2.6	0.021	3.7	YES
1981	0.095	0.089	184	-0.006	-6.3	0.006	6.7	YES
	0.236	0.235	196	-0.001	-0.4	0.012	5.1	NO
1982	0.095	0.091	139	-0.004	-4.2	0.004	4.4	YES
	0.123	0.116	79	-0.007	-5.7	0.009	7.8	YES
	0.234	0.223	233	-0.011	-4.7	0.017	7.6	YES
1983	0.123	0.111	149	-0.012	-9.8	0.006	5.4	YES
	0.153	0.149	170	-0.004	-2.6	0.006	4.0	NO
	0.215	0.205	169	-0.010	-4.7	0.008	3.9	YES
	0.237	0.209	145	-0.028	-11.8	0.010	4.8	YES

a. number of replicates
b. 95% confidence level

APPENDIX D
Replicate Sample Analyses
Plots and Tables
1978-1983

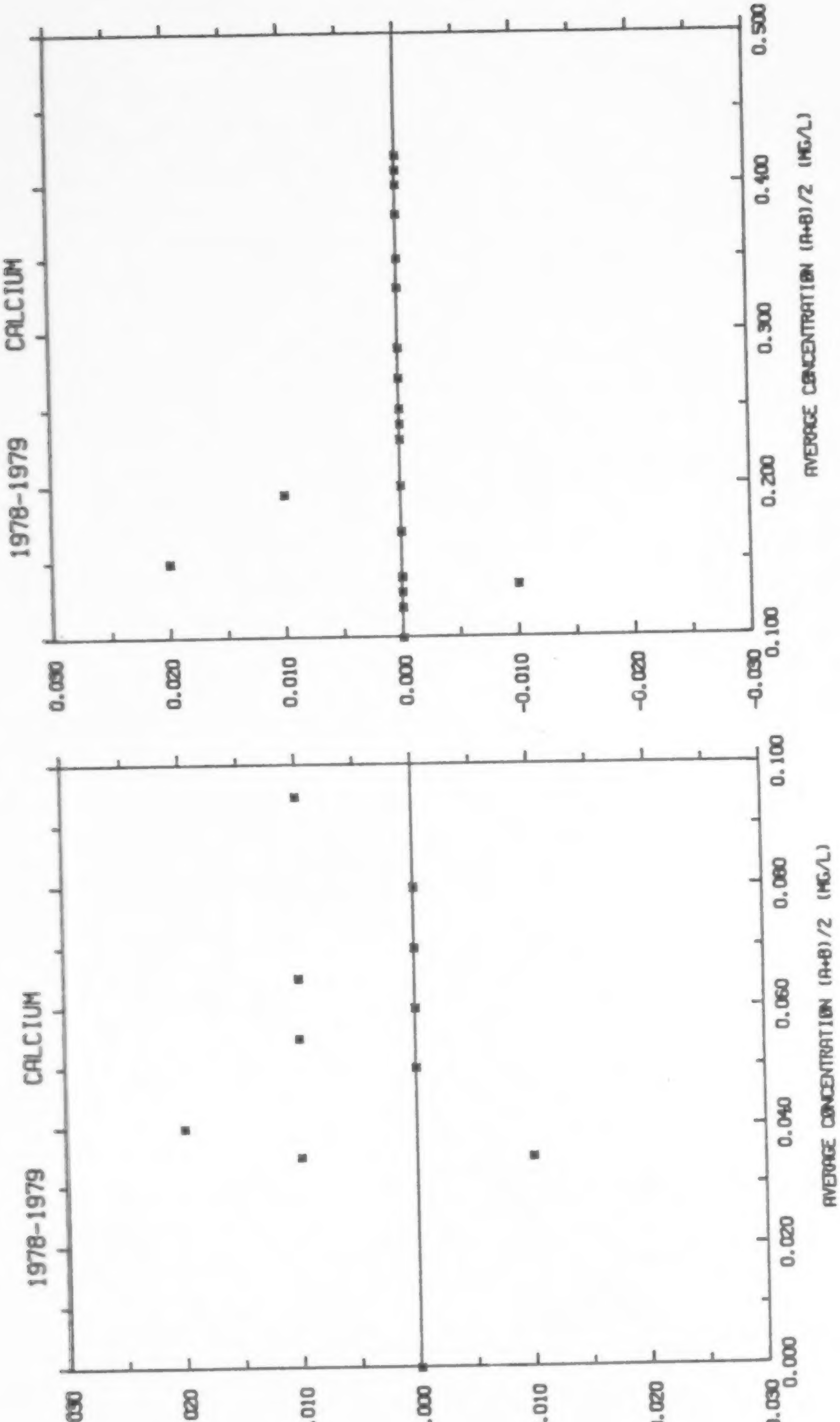


FIGURE 1. Replicate plots for calcium for 1978 and 1979.

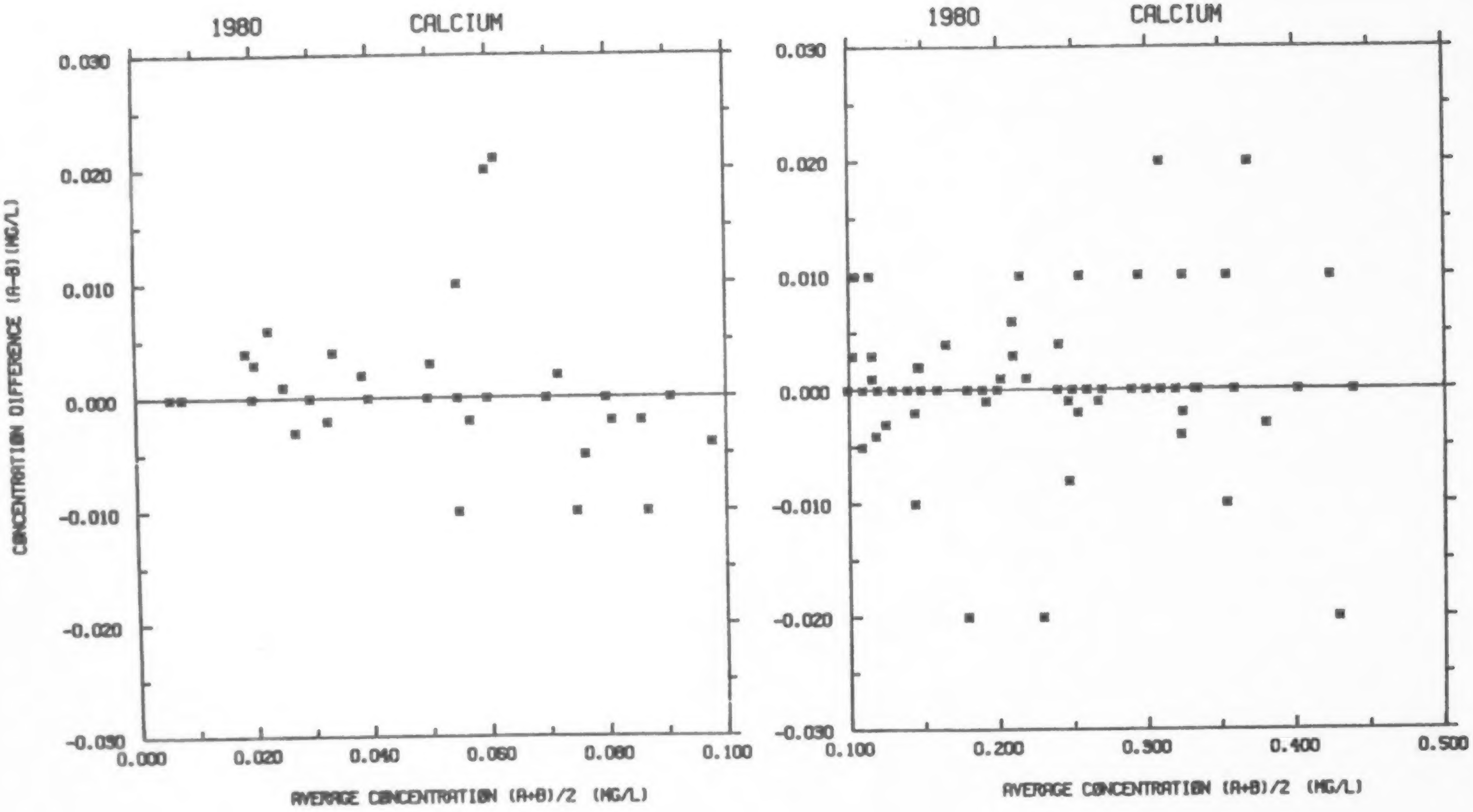


FIGURE 2. Replicate plots for calcium for 1980.

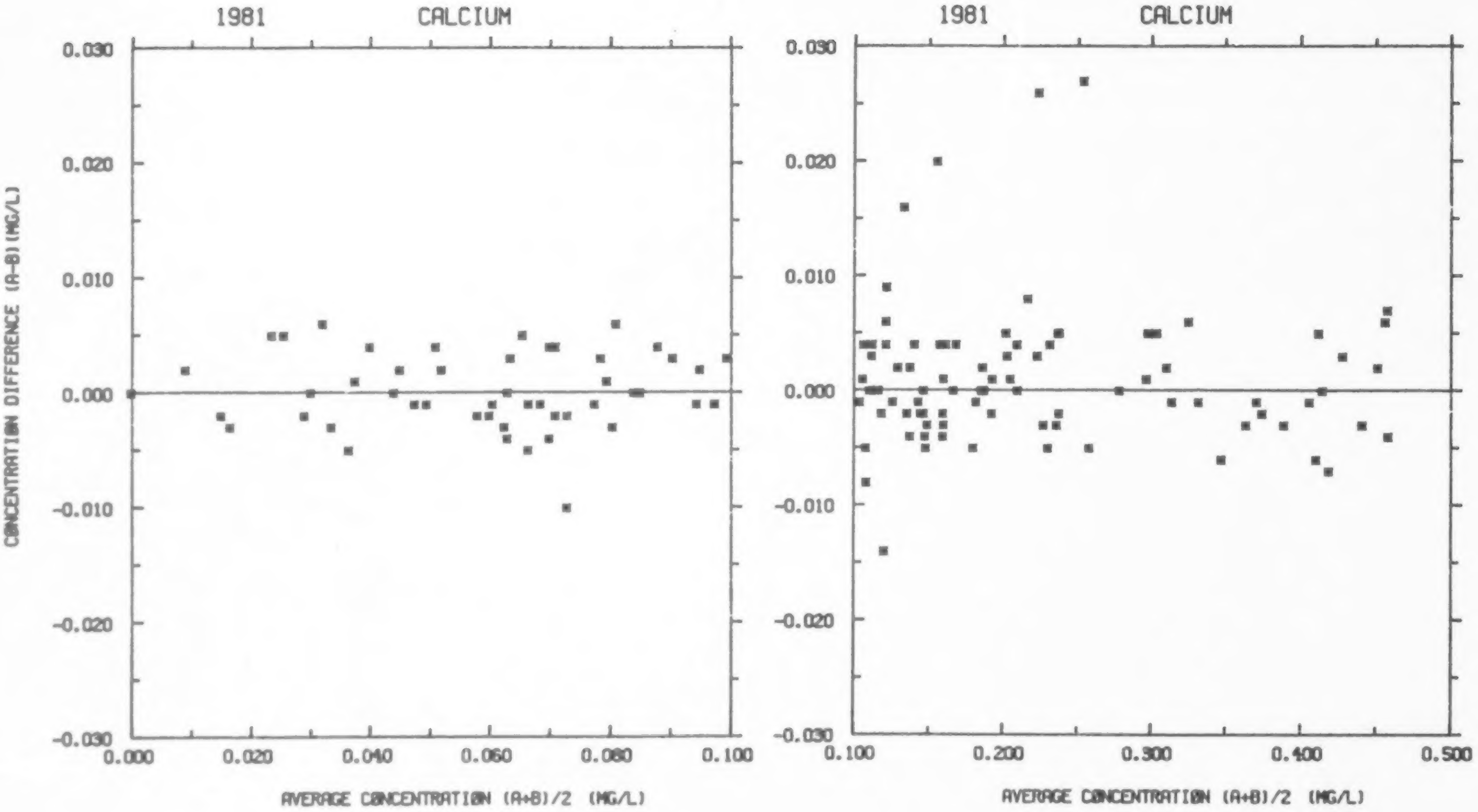


FIGURE 3. Replicate plots for calcium for 1981.

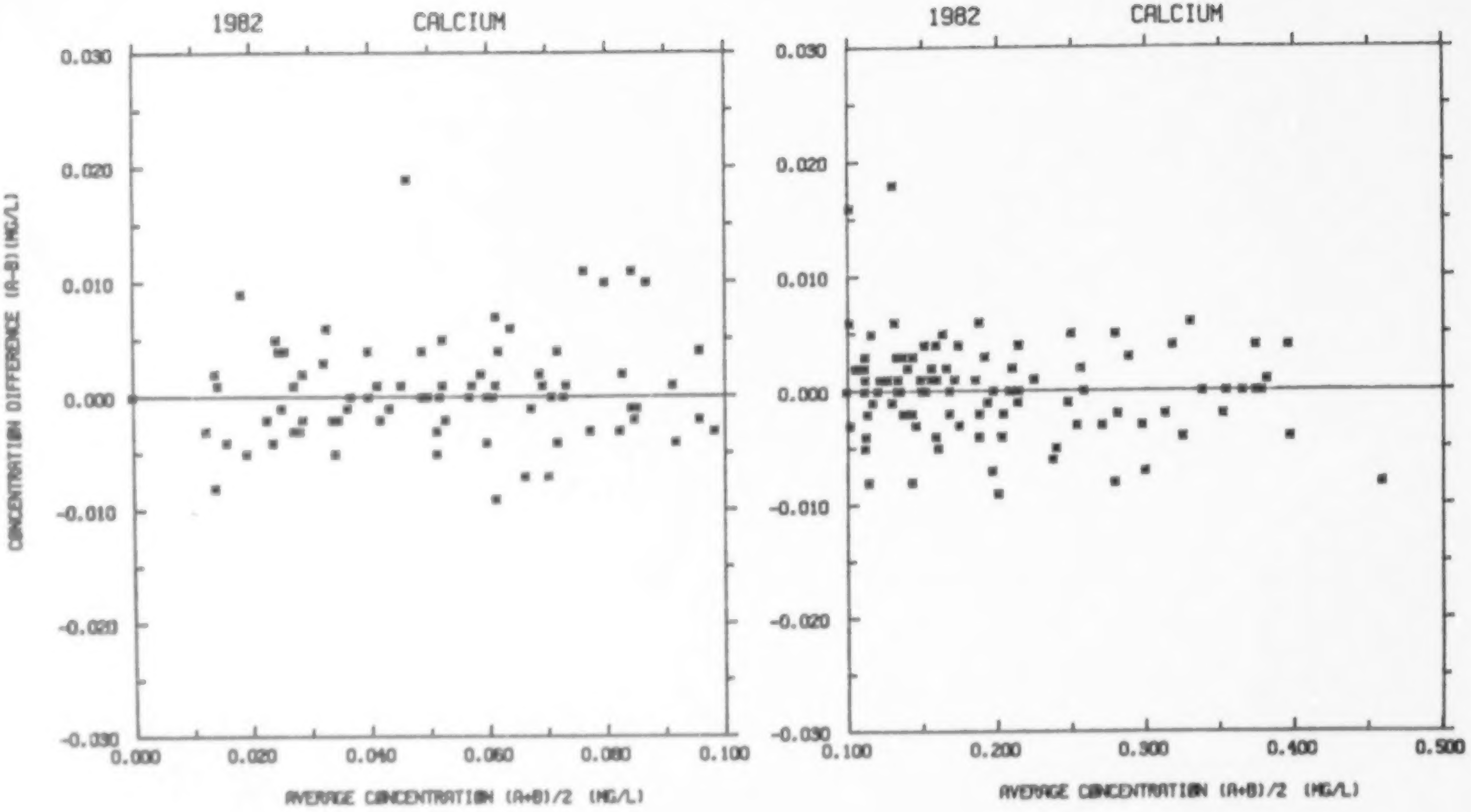


FIGURE 4. Replicate plots for calcium for 1982.

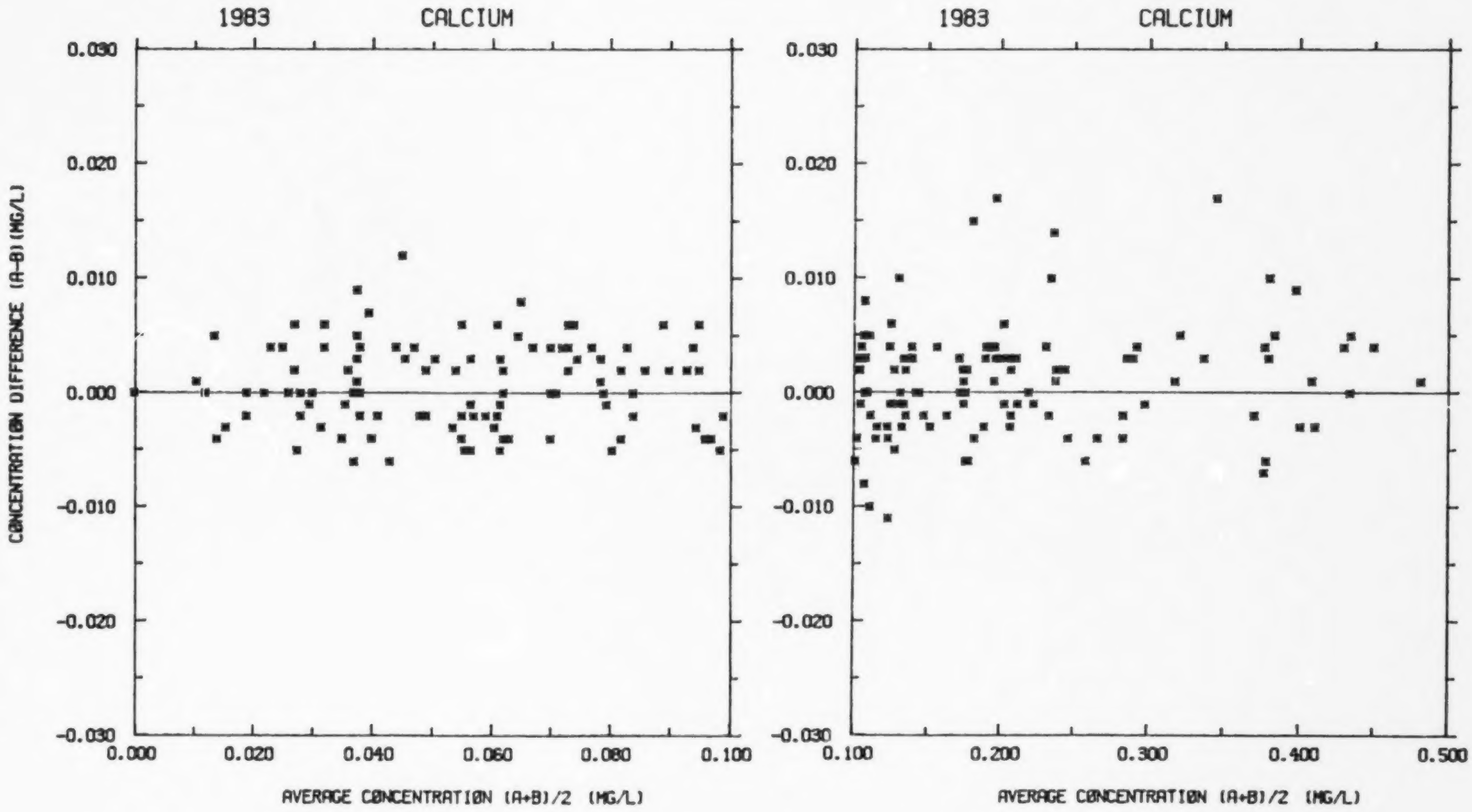


FIGURE 5. Replicate plots for calcium for 1983.

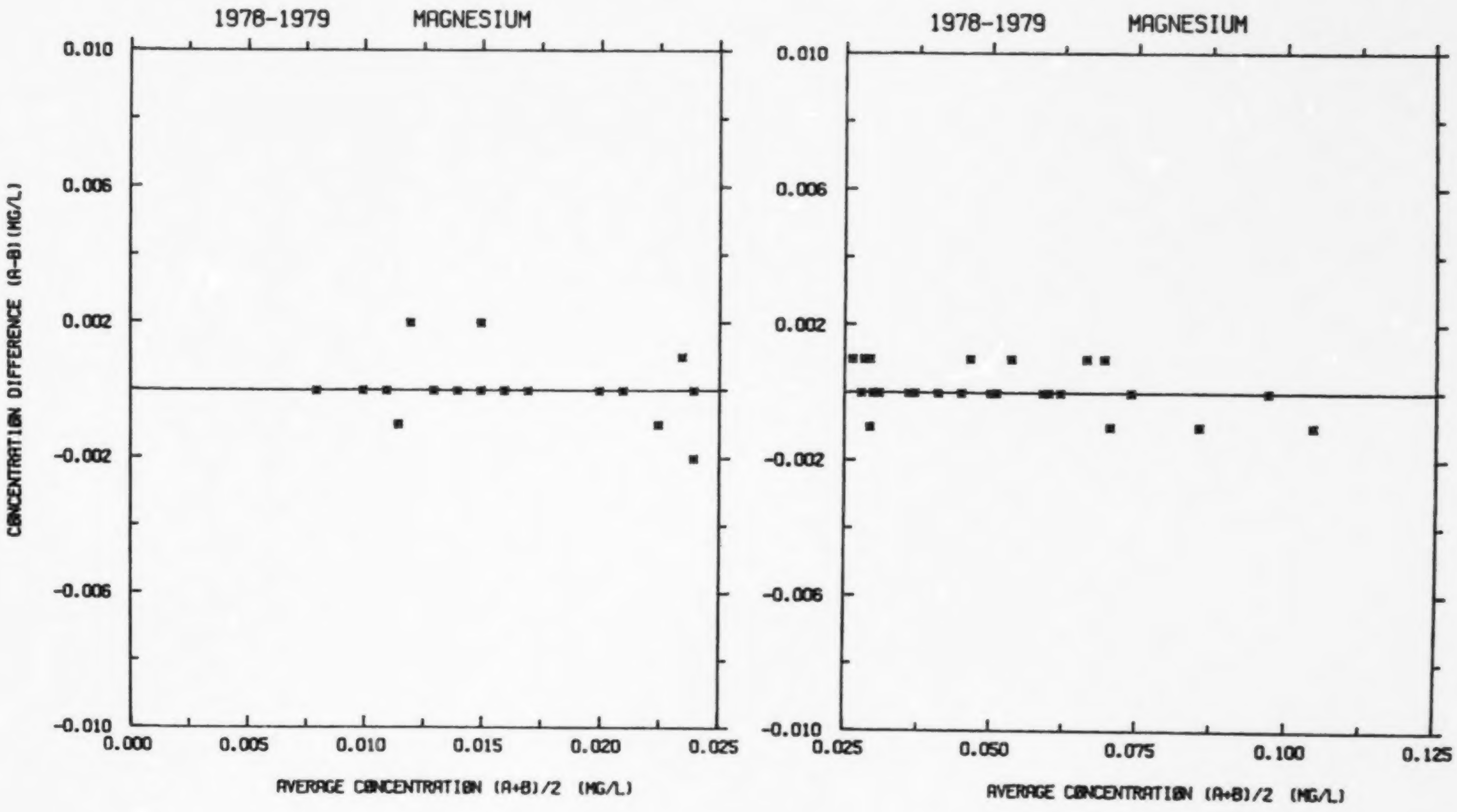


FIGURE 6. Replicate plots for magnesium for 1978 and 1979.

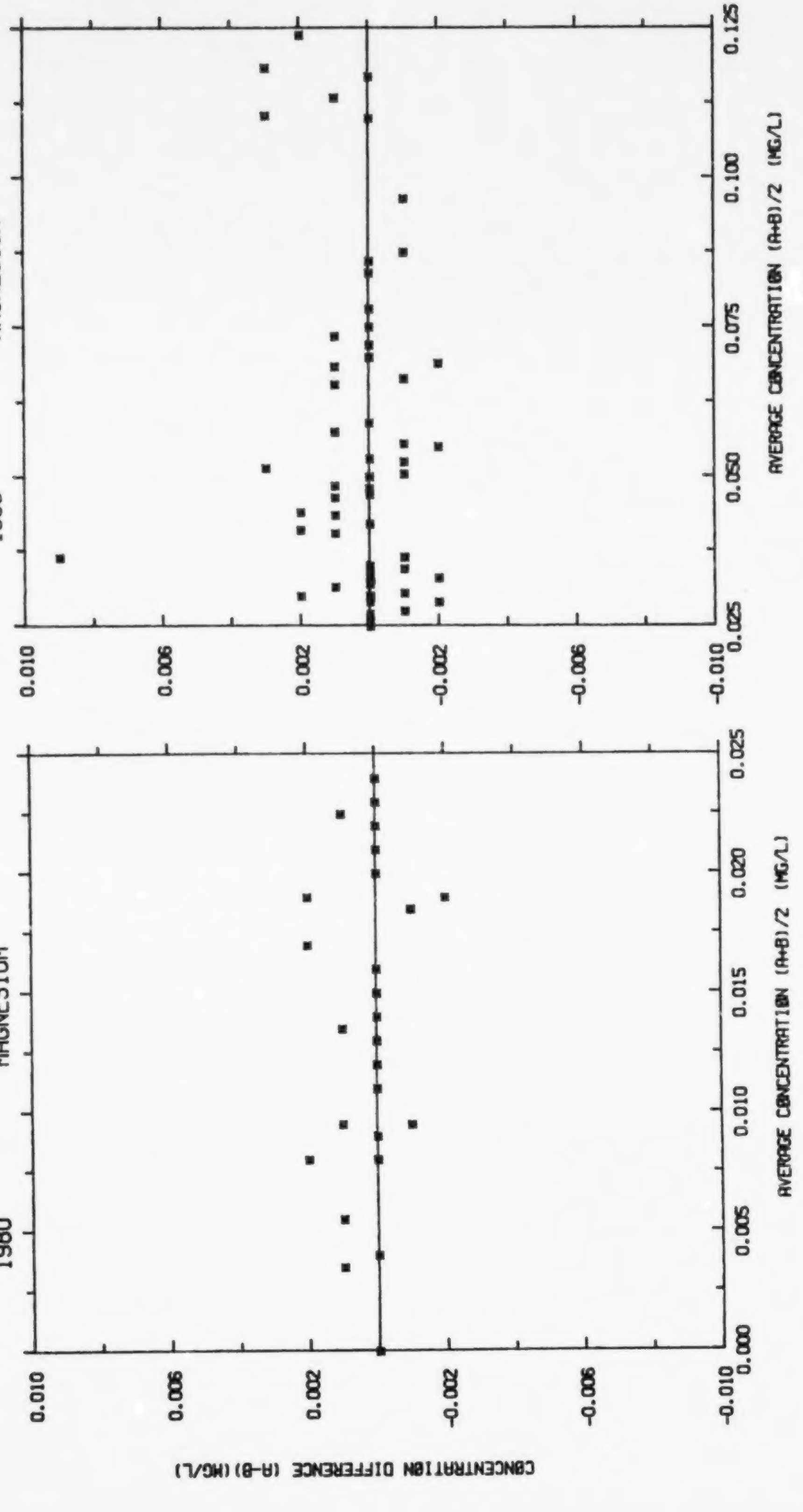


FIGURE 7. Replicate plots for magnesium for 1980.

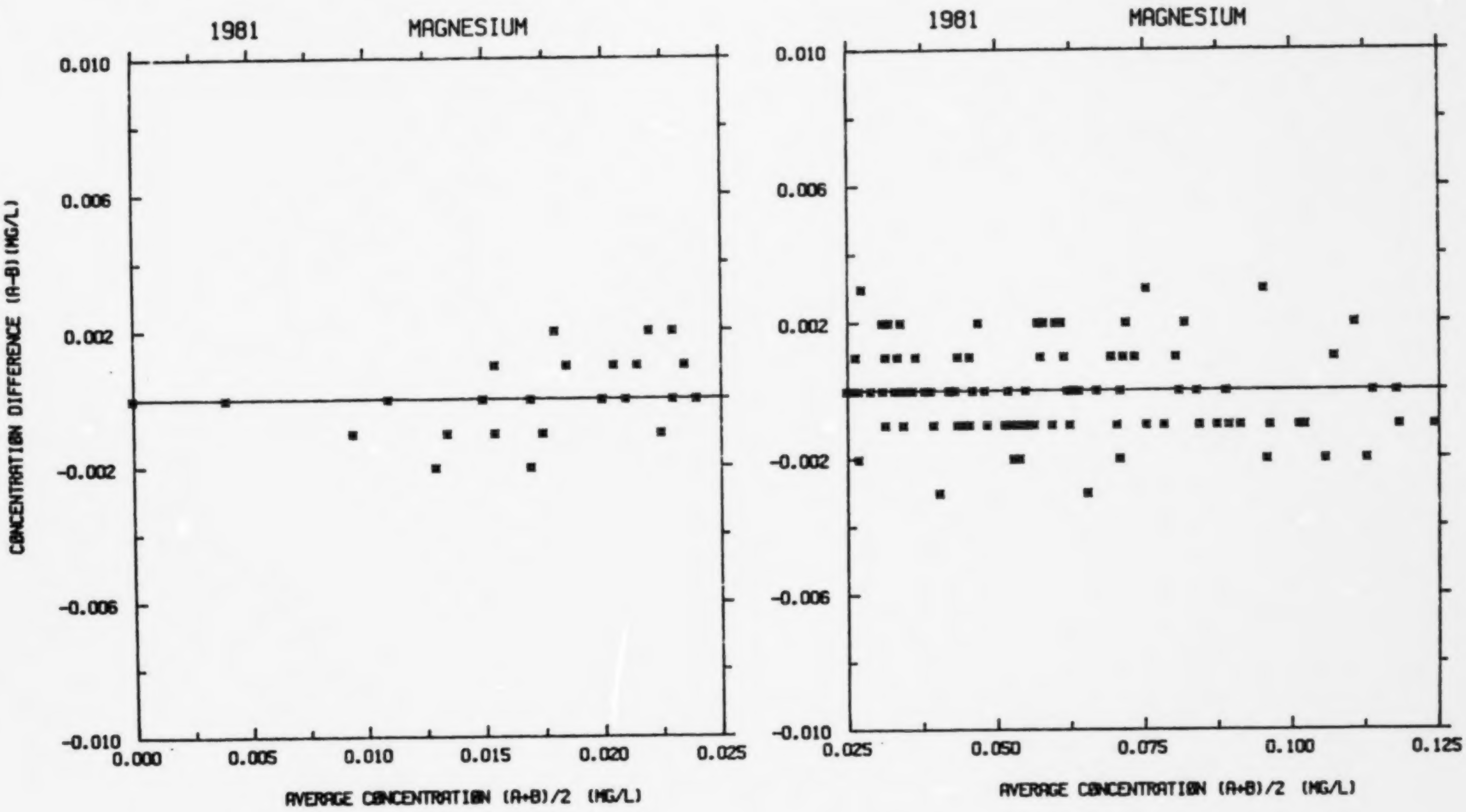


FIGURE 8. Replicate plots for magnesium for 1981.

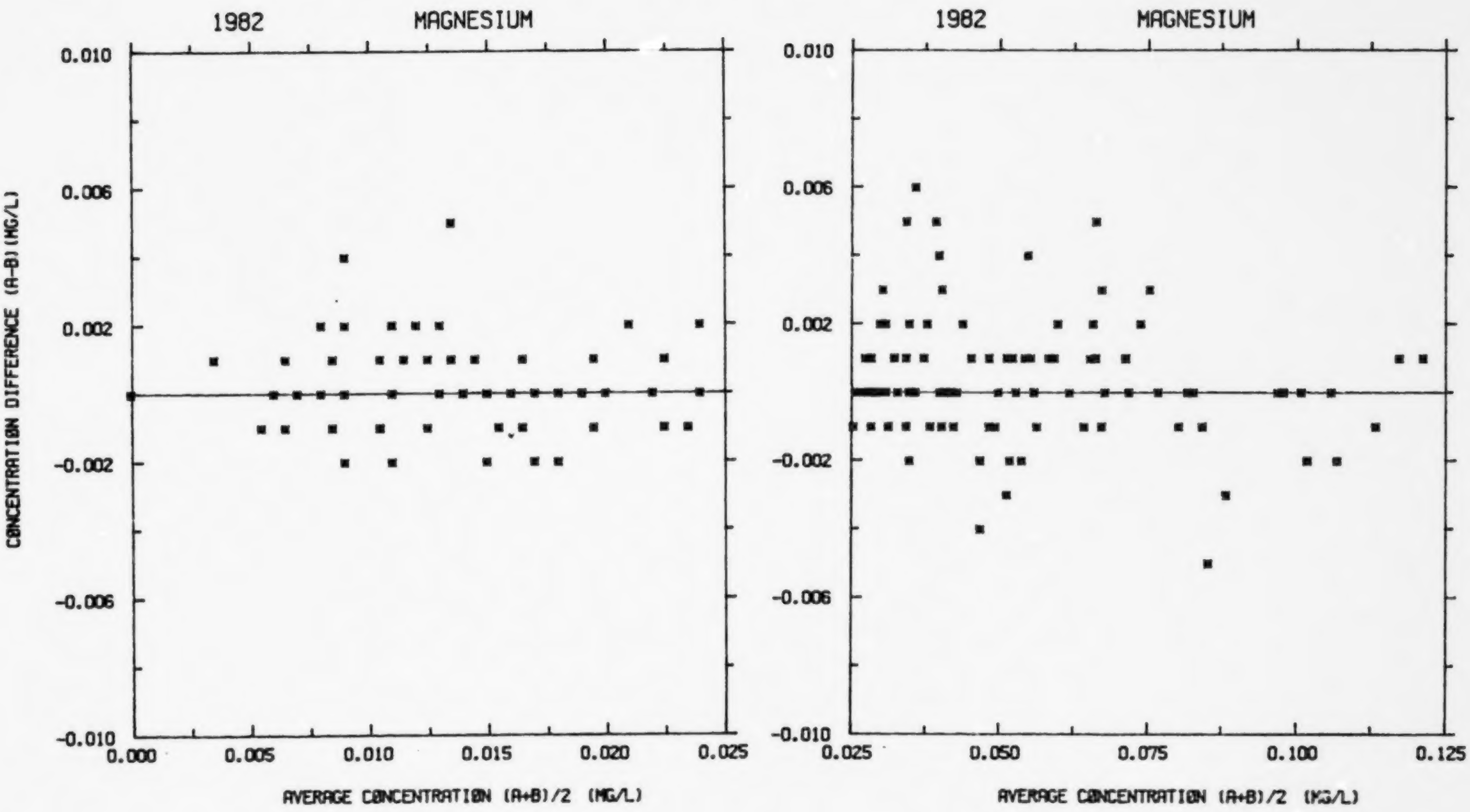


FIGURE 9. Replicate plots for magnesium for 1982.

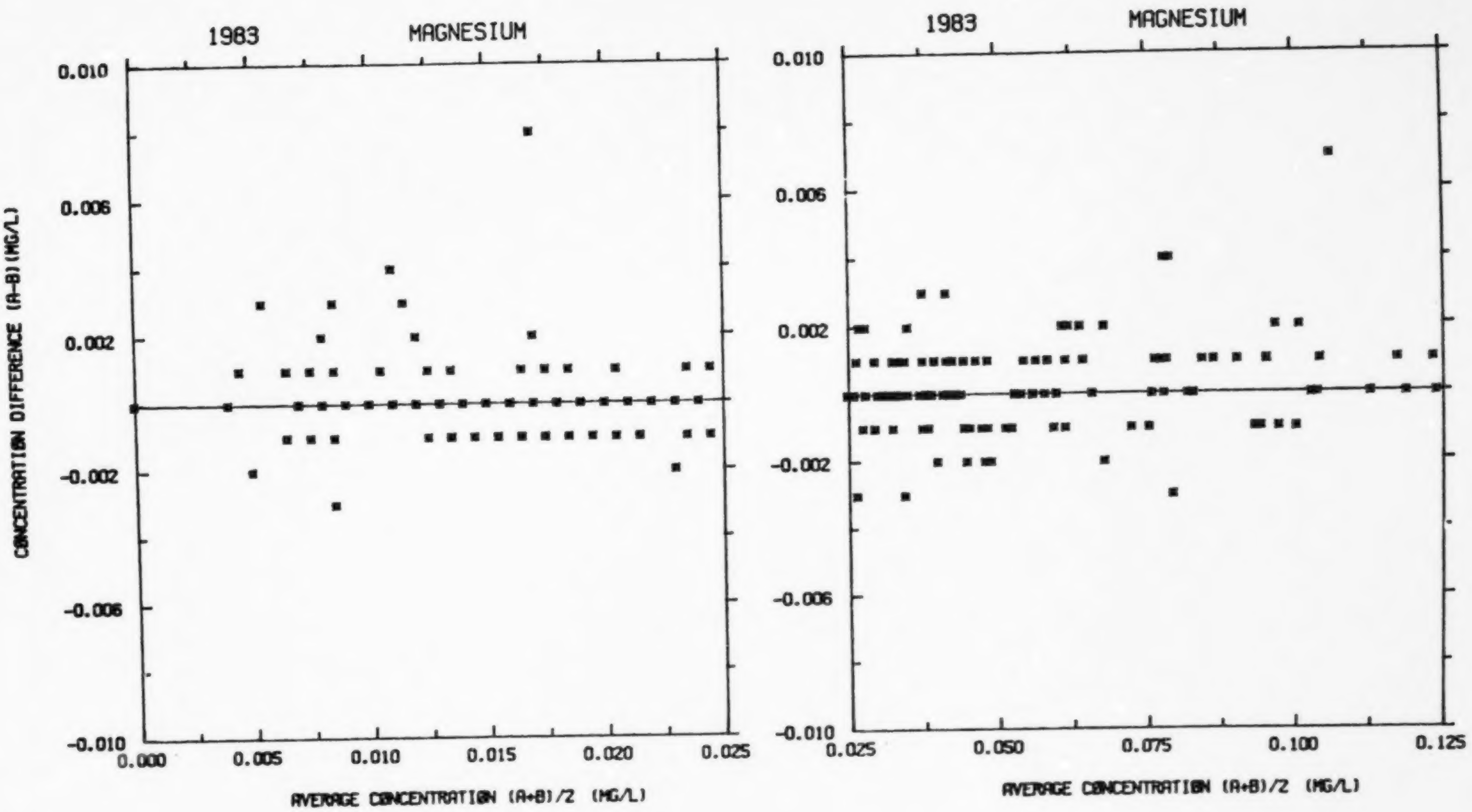


FIGURE 10. Replicate plots for magnesium for 1983.

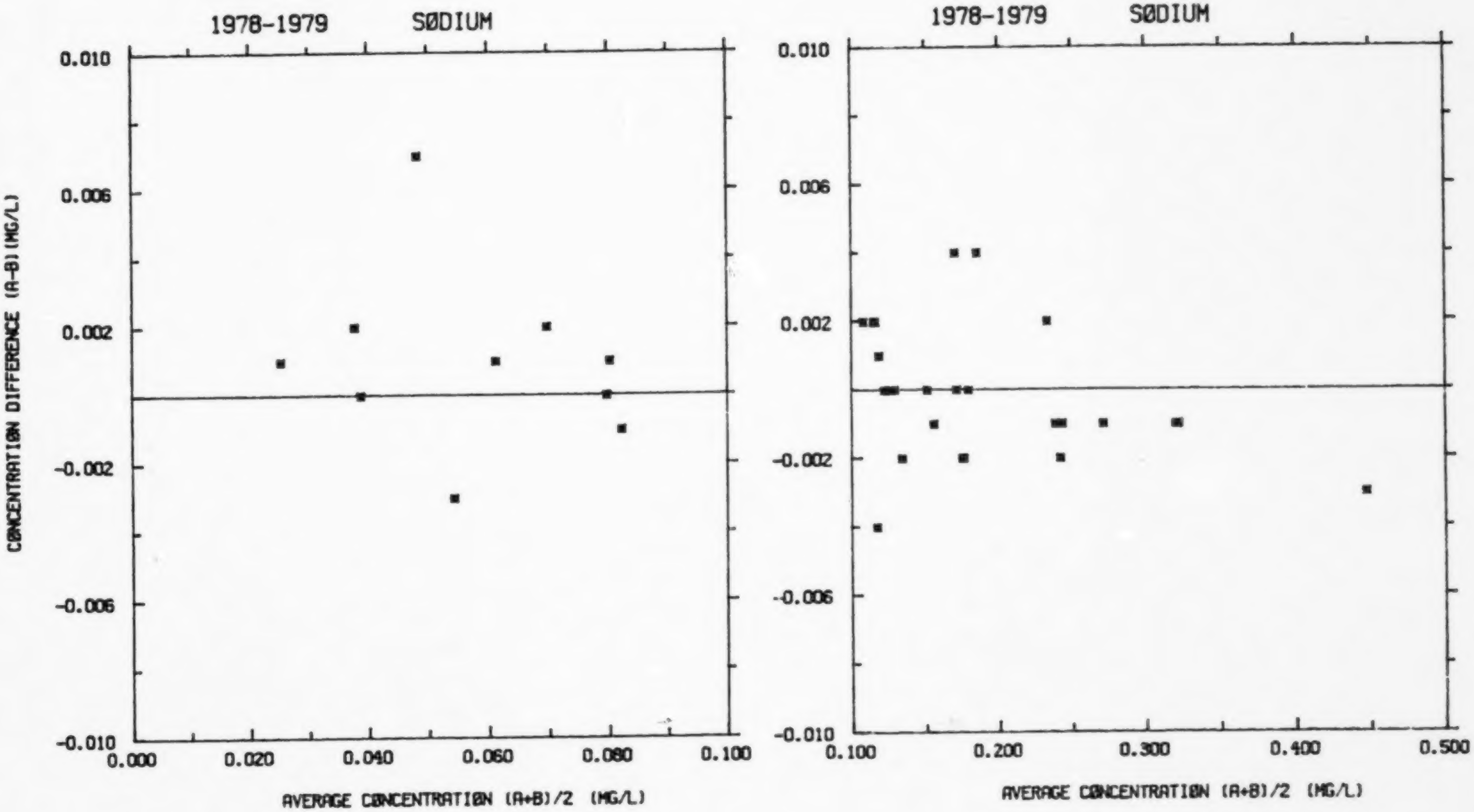


FIGURE 11. Replicate plots for sodium for 1978 and 1979.

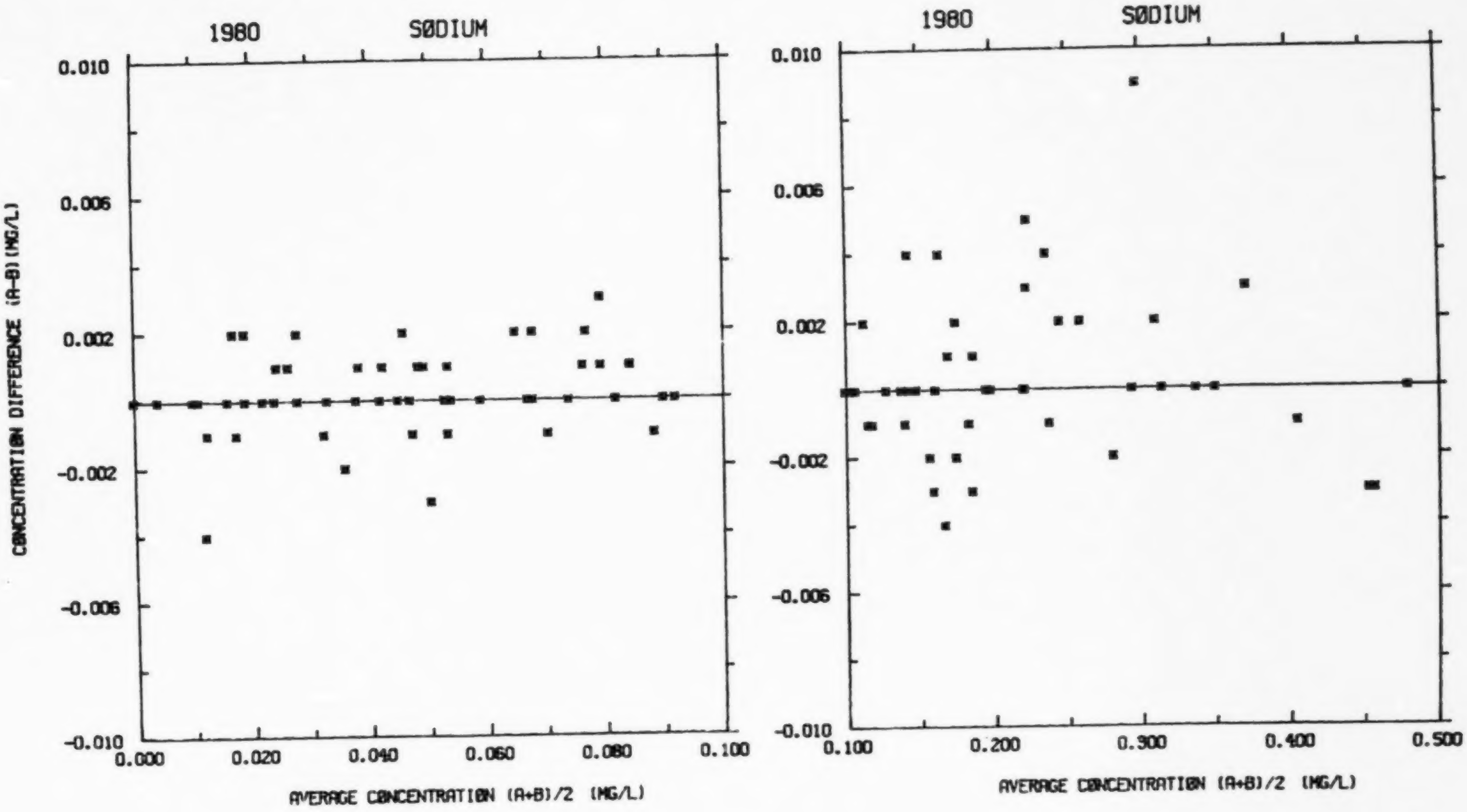


FIGURE 12. Replicate plots for sodium for 1980.

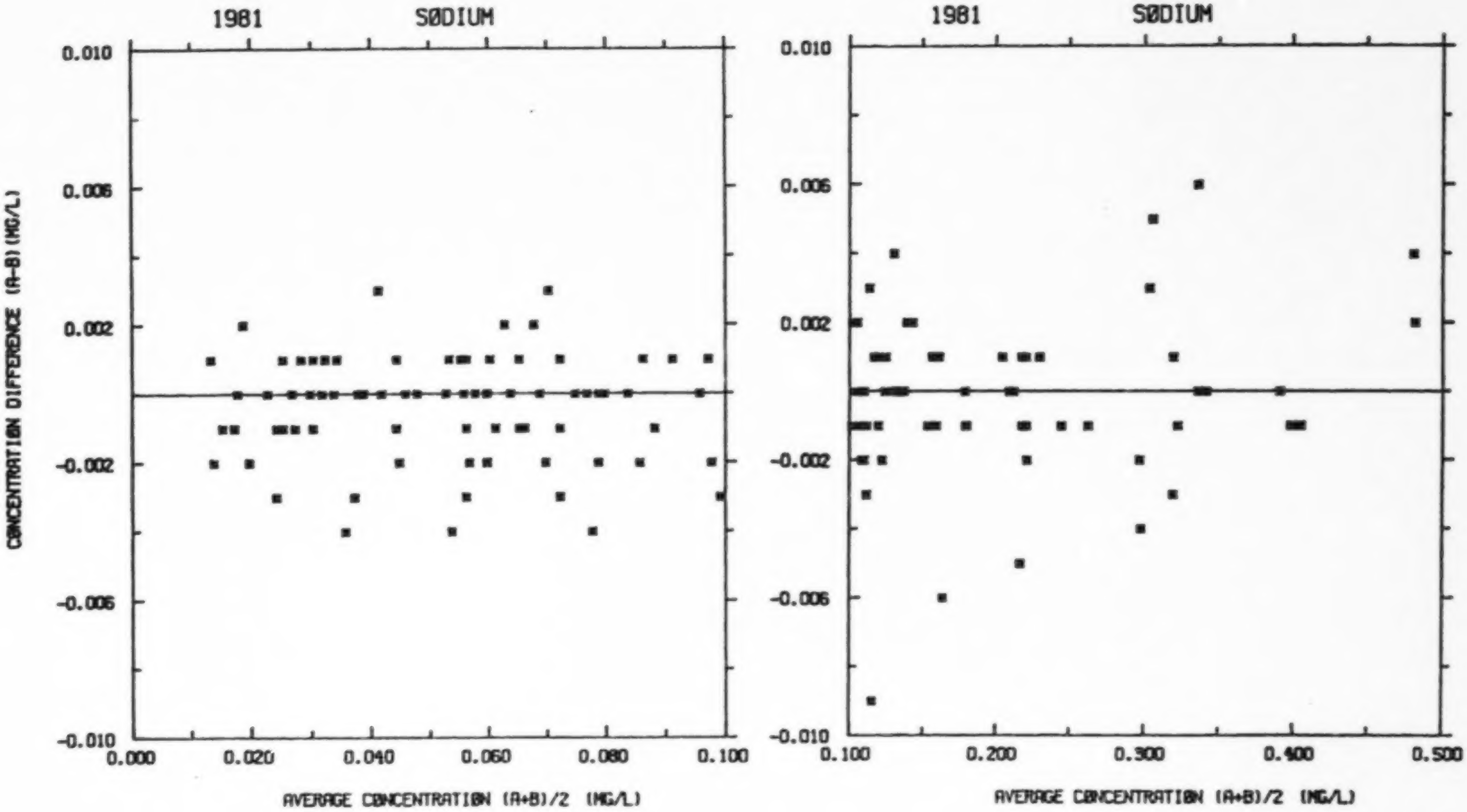


FIGURE 13. Replicate plots for sodium for 1981.

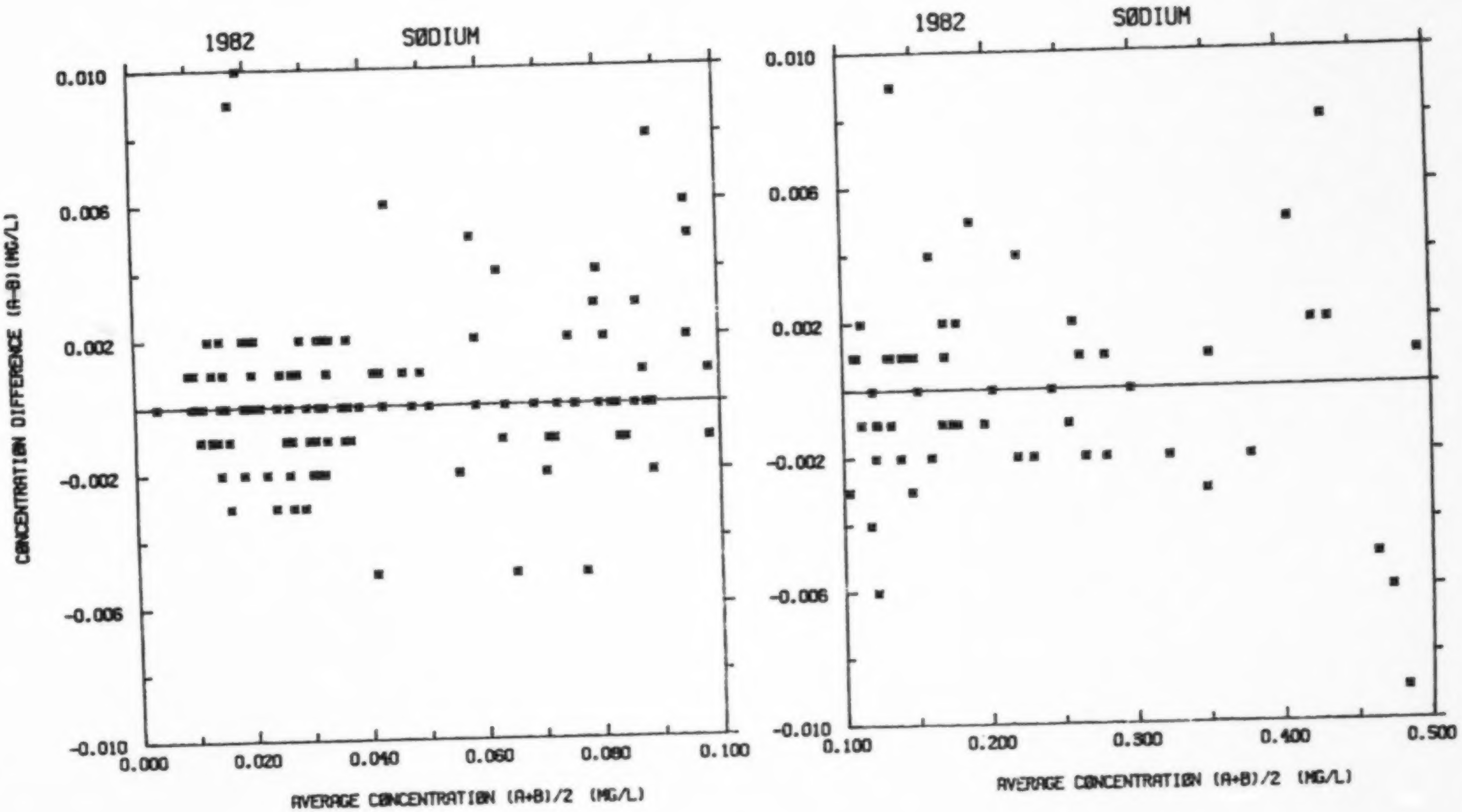


FIGURE 14. Replicate plots for sodium for 1982.

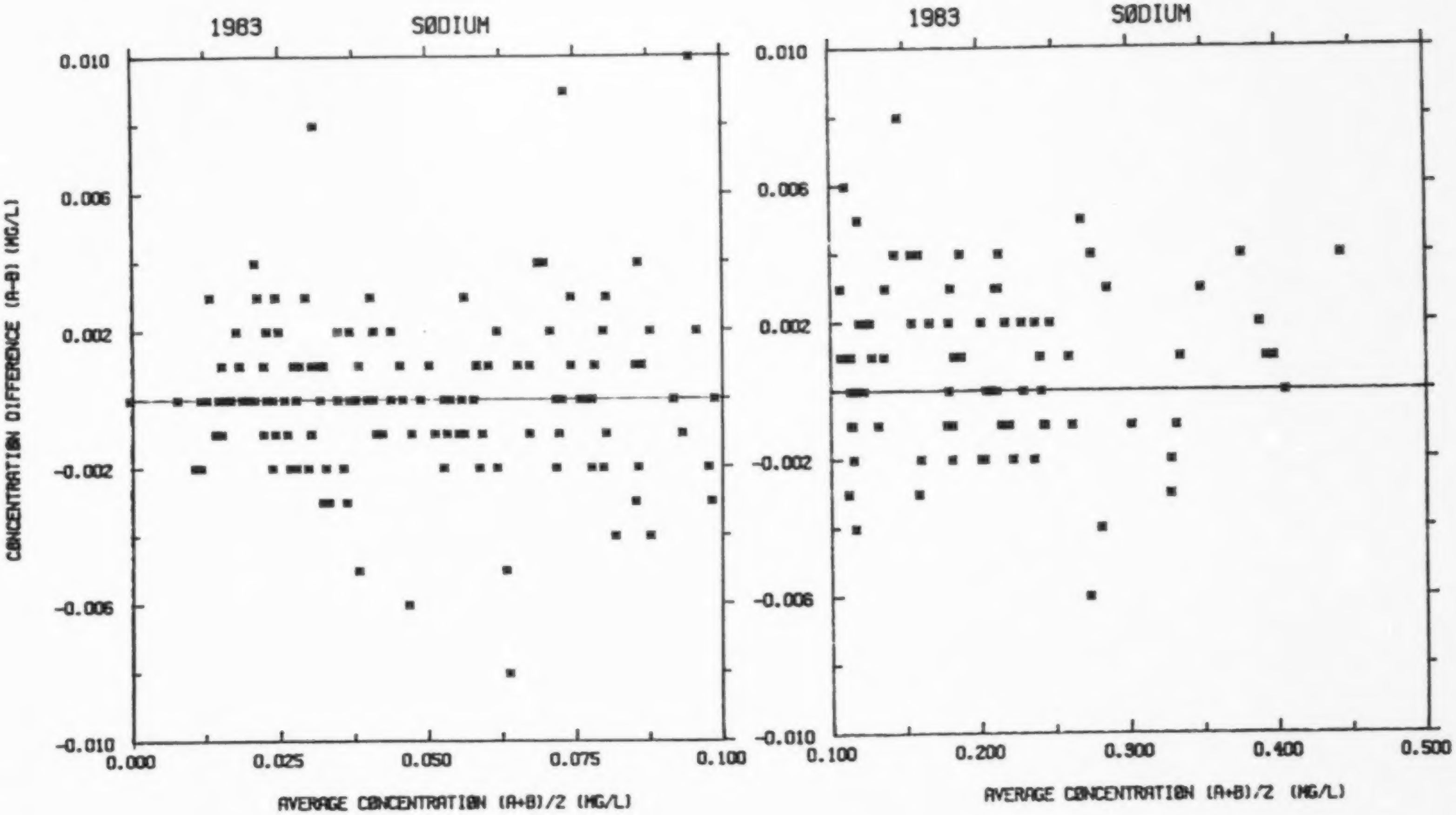


FIGURE 15. Replicate plots for sodium for 1983.

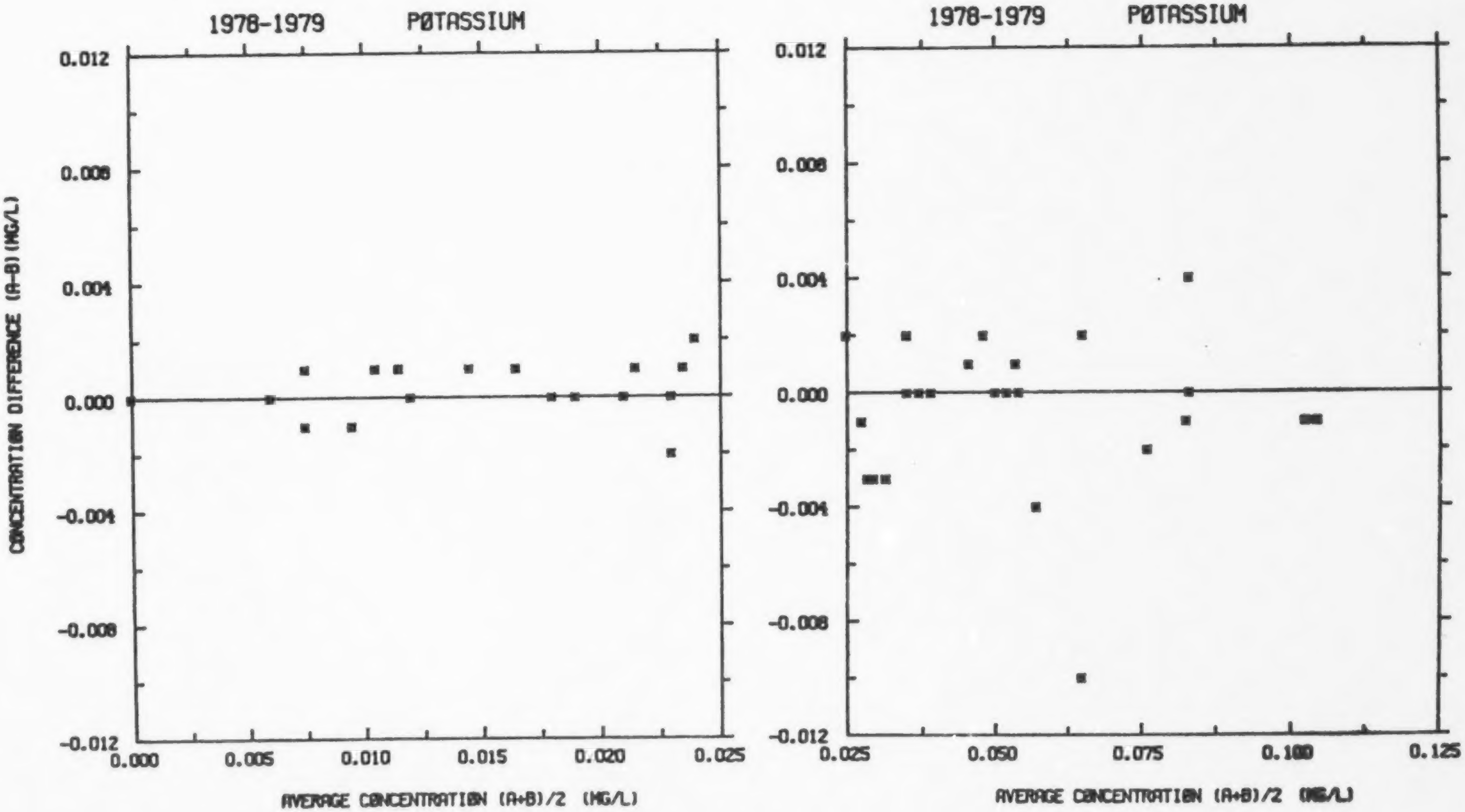


FIGURE 16. Replicate plots for potassium for 1978 and 1979.

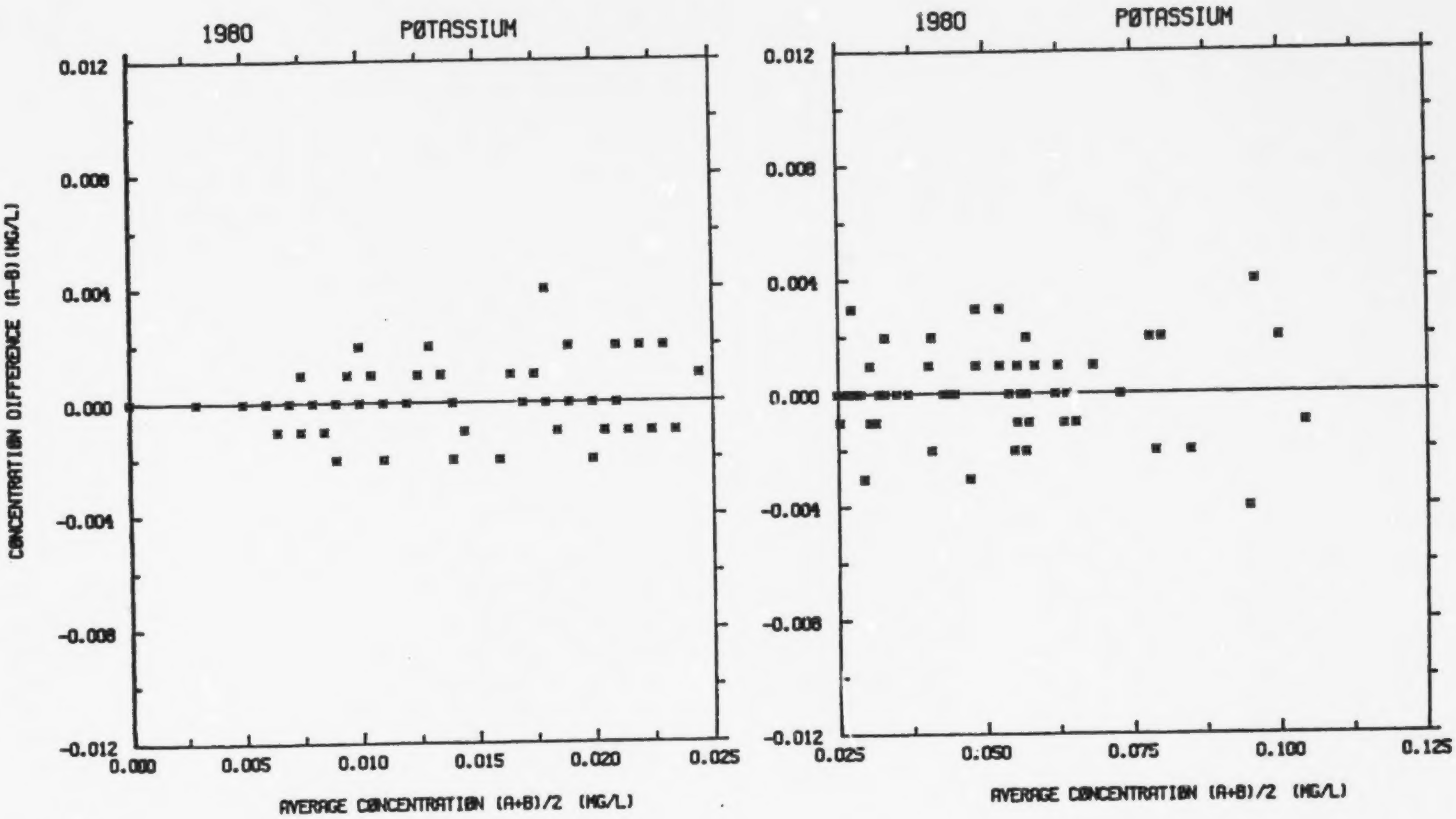


FIGURE 17. Replicate plots for potassium for 1980.

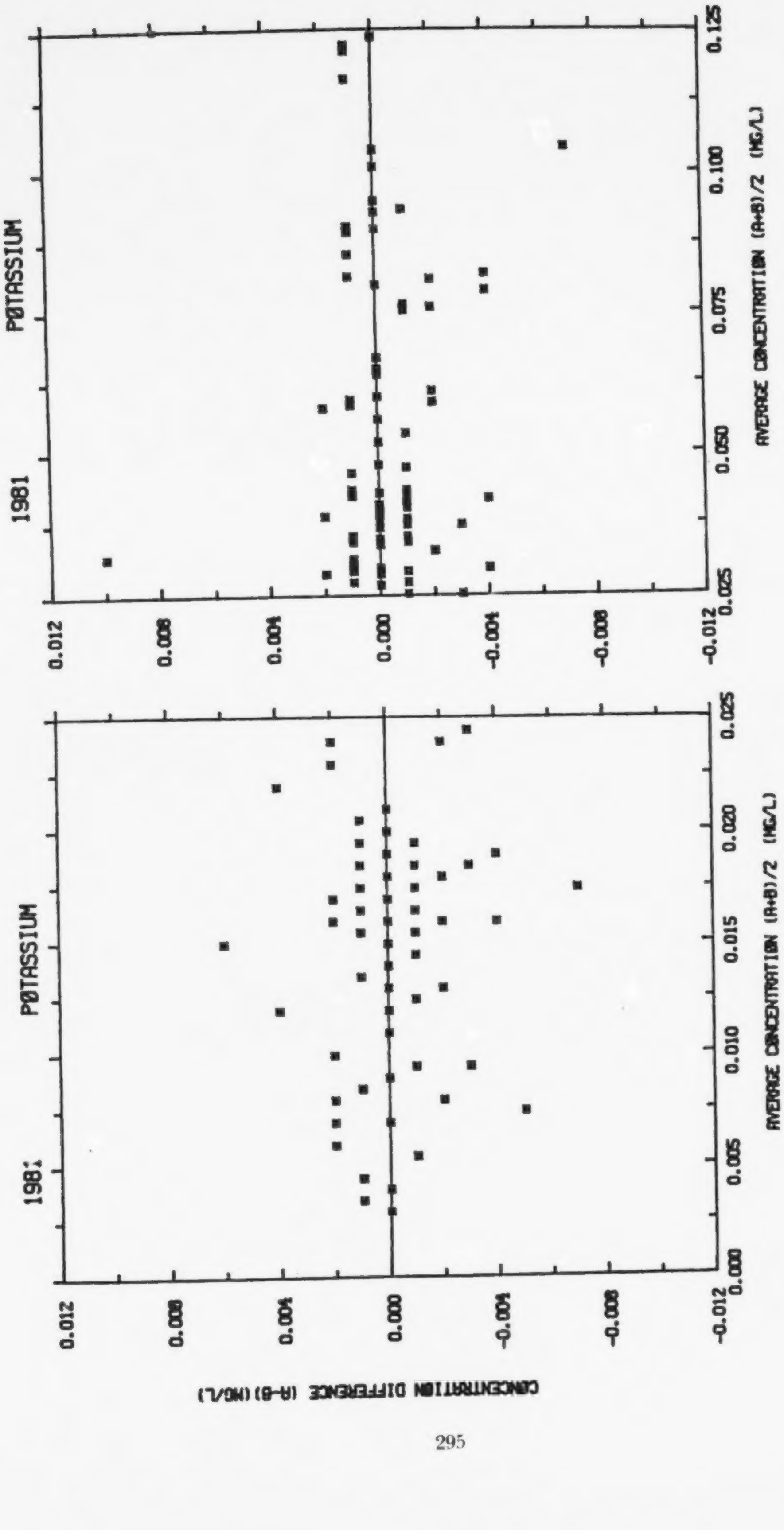


FIGURE 18. Replicate plots for potassium for 1981.

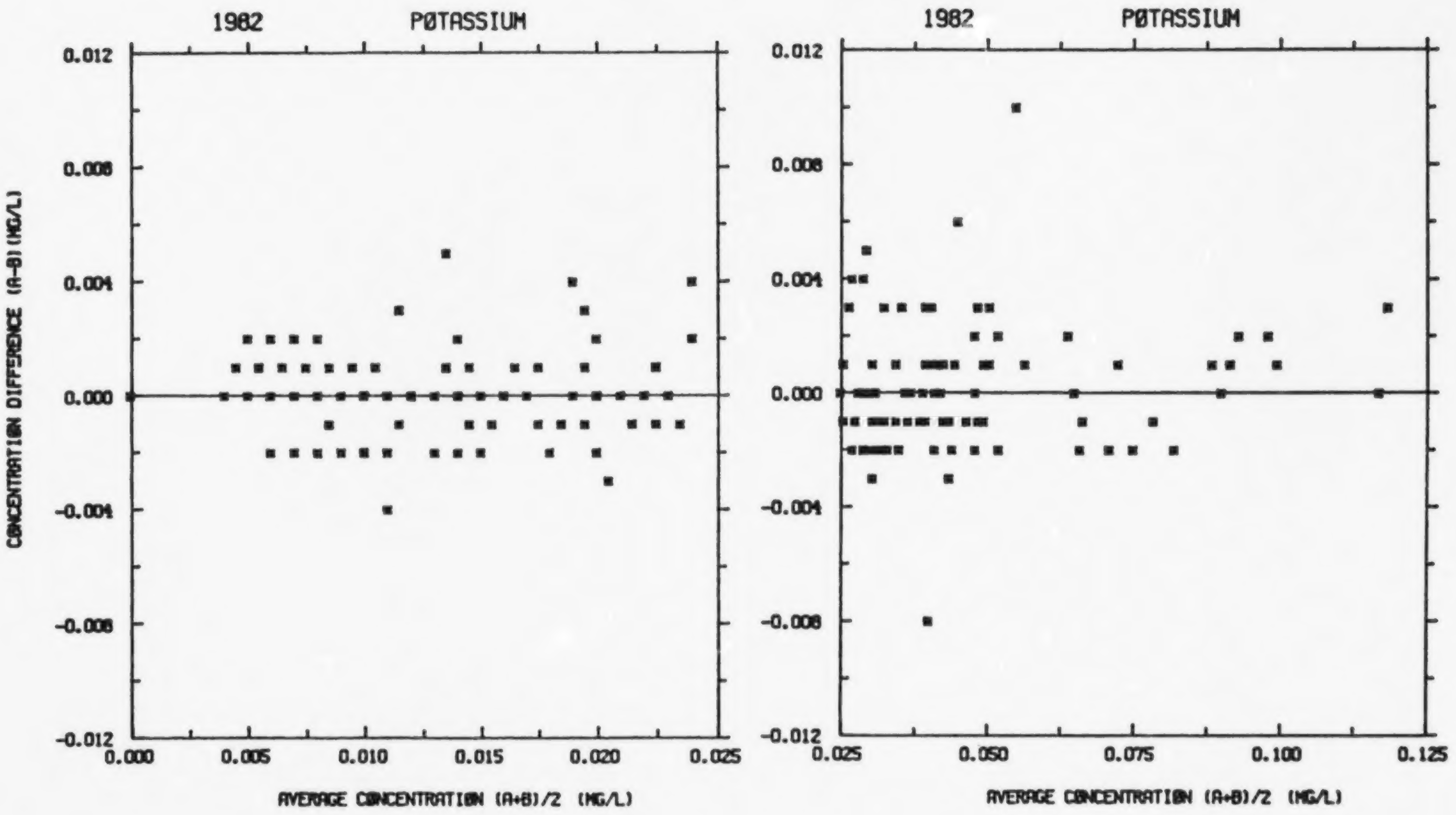


FIGURE 19. Replicate plots for potassium for 1982.

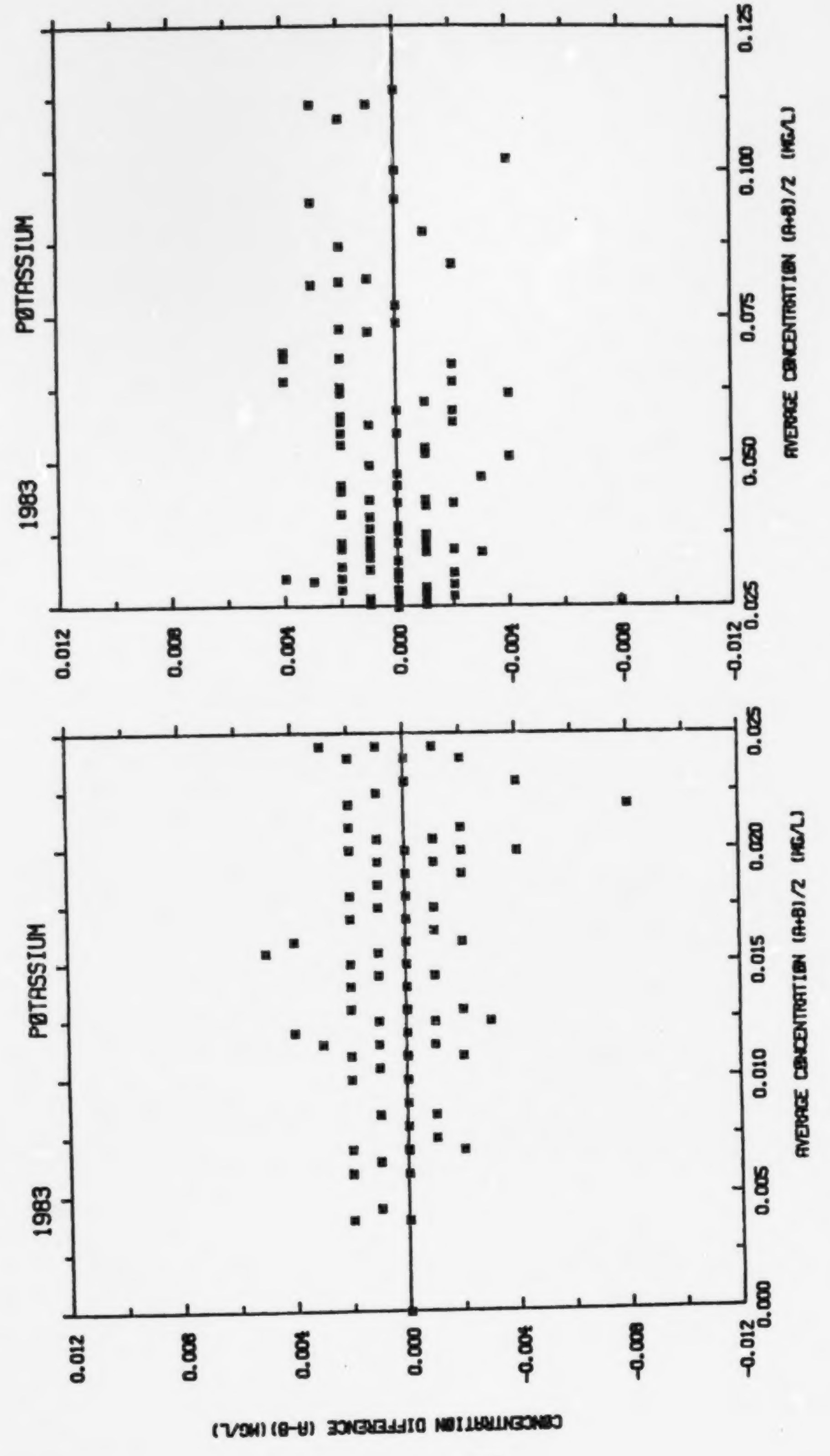


FIGURE 20. Replicate plots for potassium for 1983.

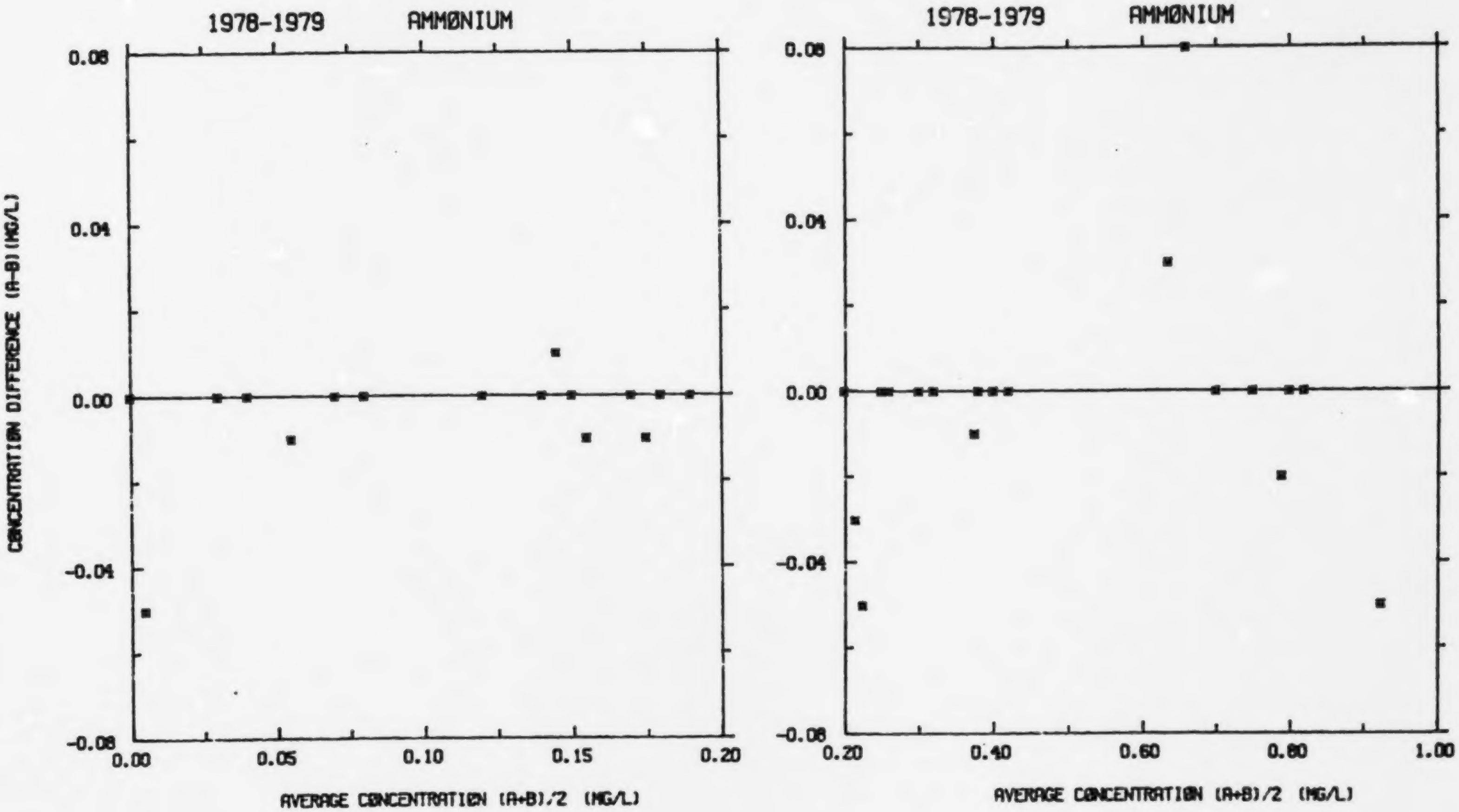


FIGURE 21. Replicate plots for ammonium for 1978 and 1979.

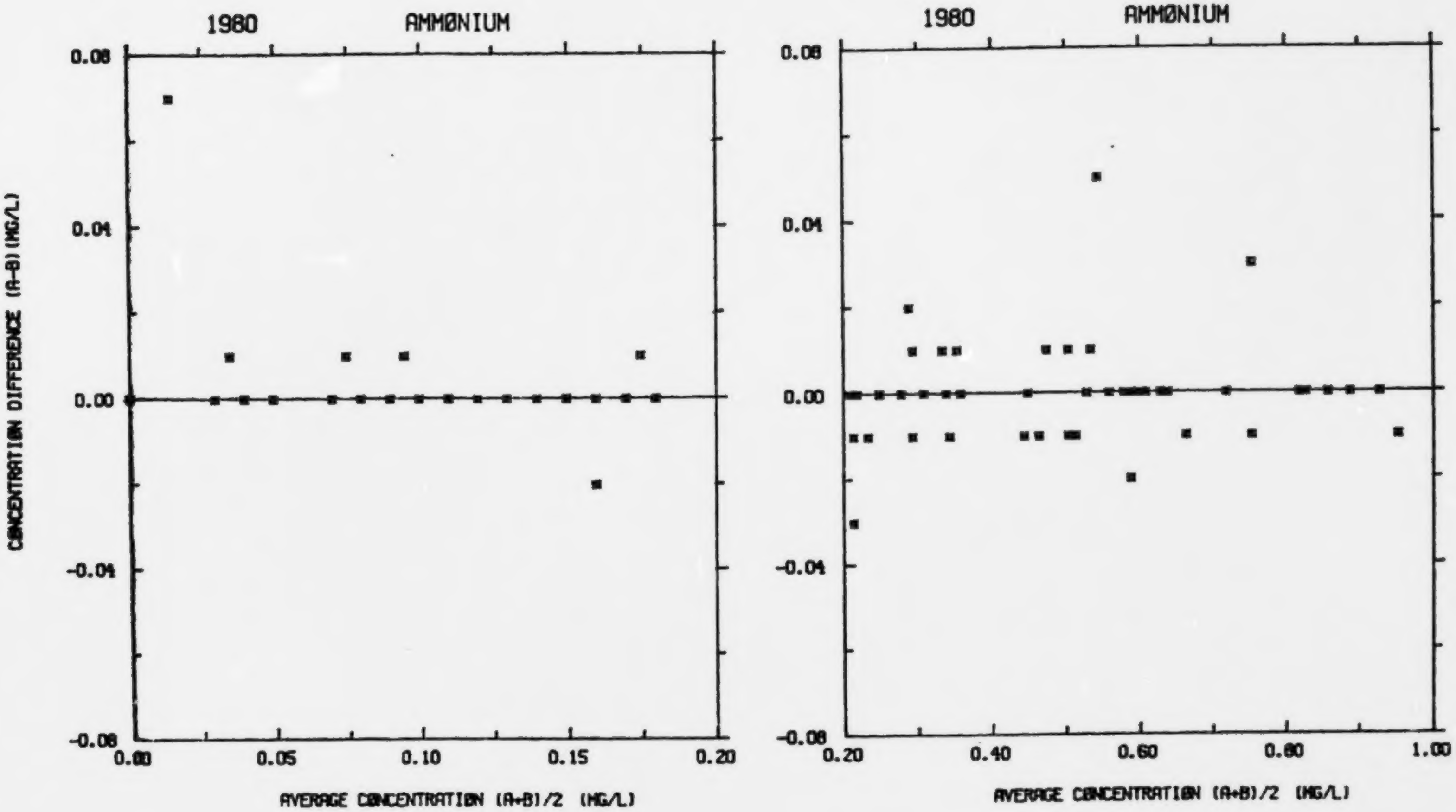


FIGURE 22. Replicate plots for ammonium for 1980.

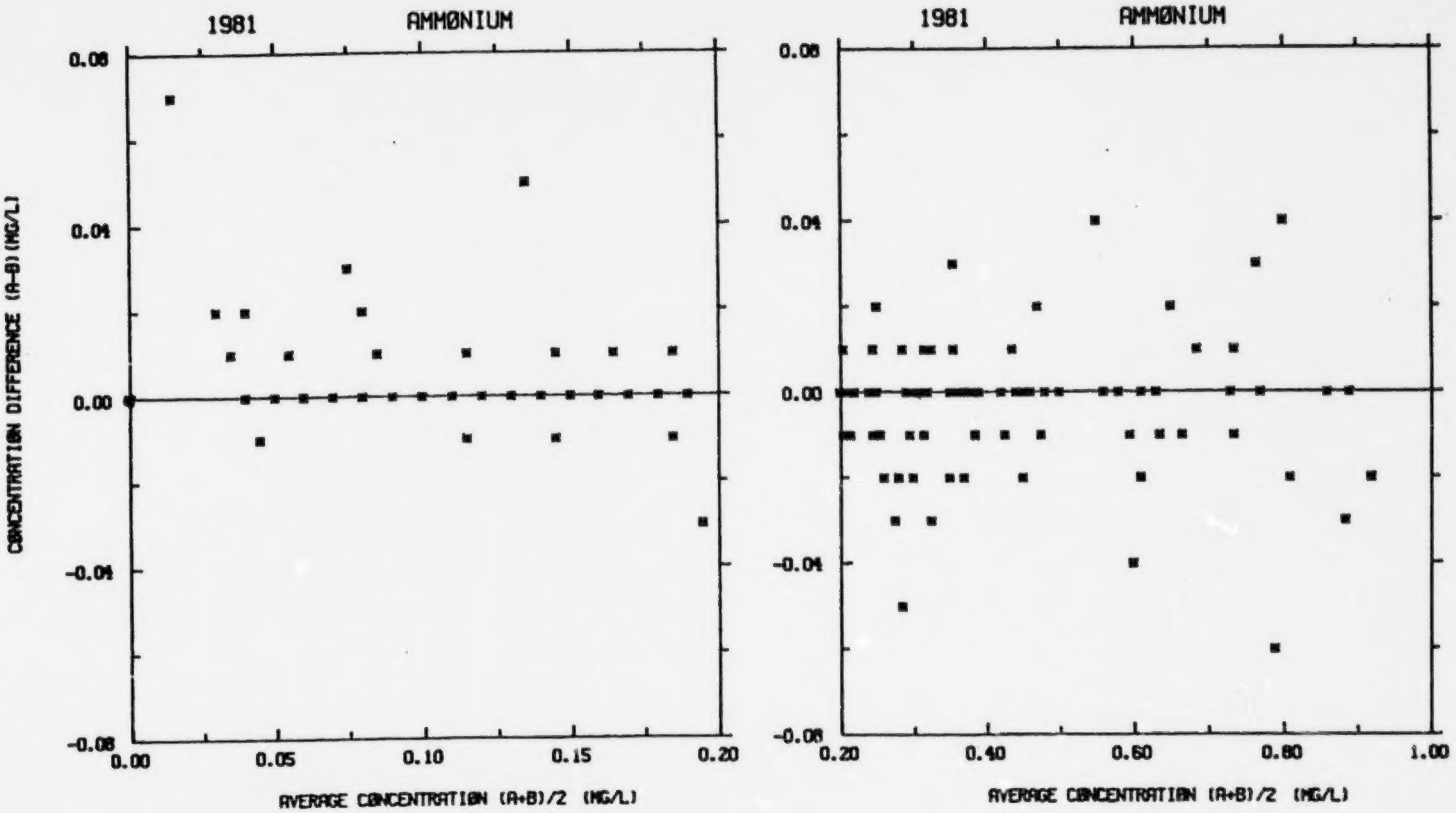


FIGURE 23. Replicate plots for ammonium for 1981.

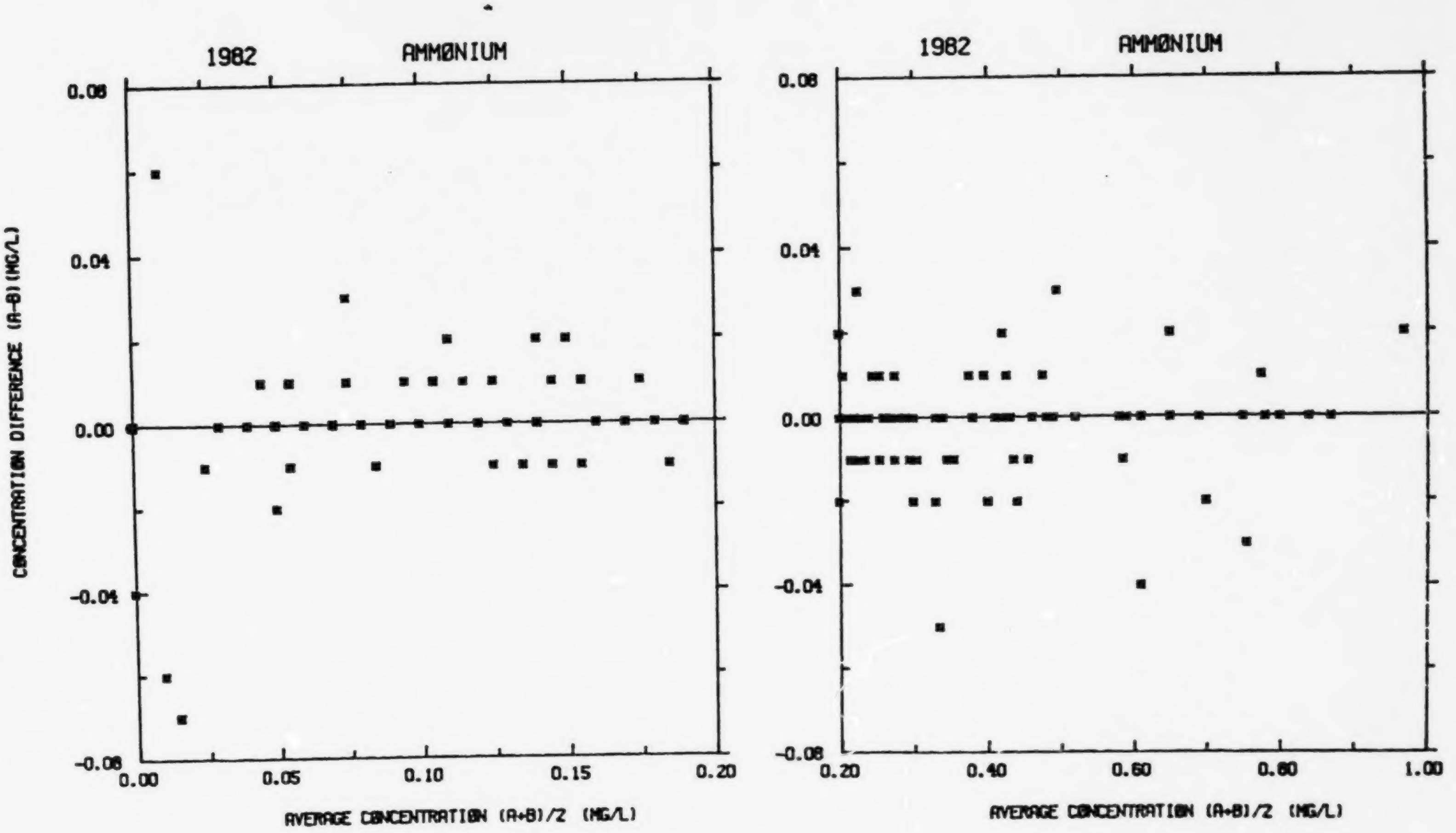


FIGURE 24. Replicate plots for ammonium for 1982.

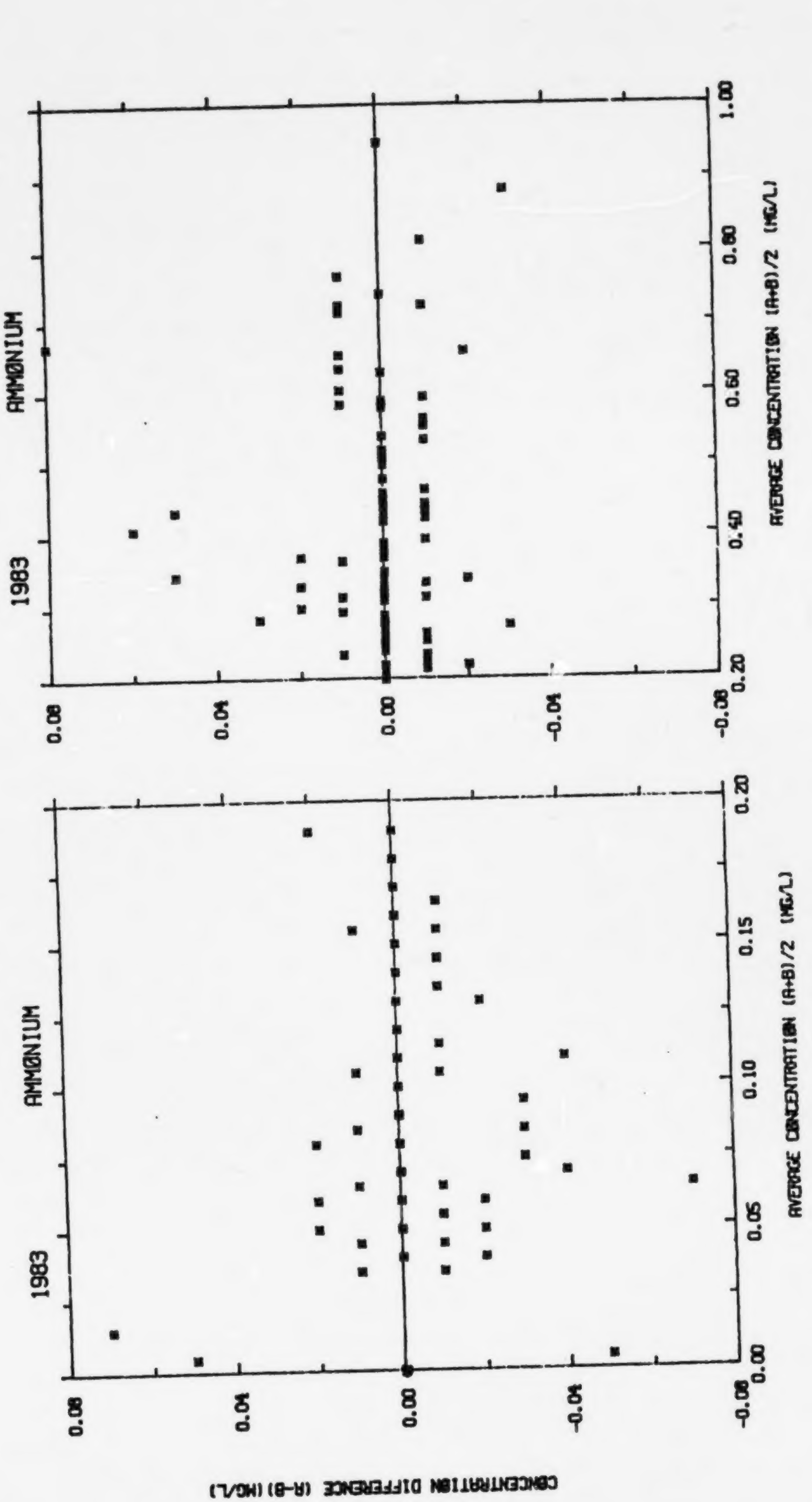


FIGURE 25. Replicate plots for ammonium for 1983.

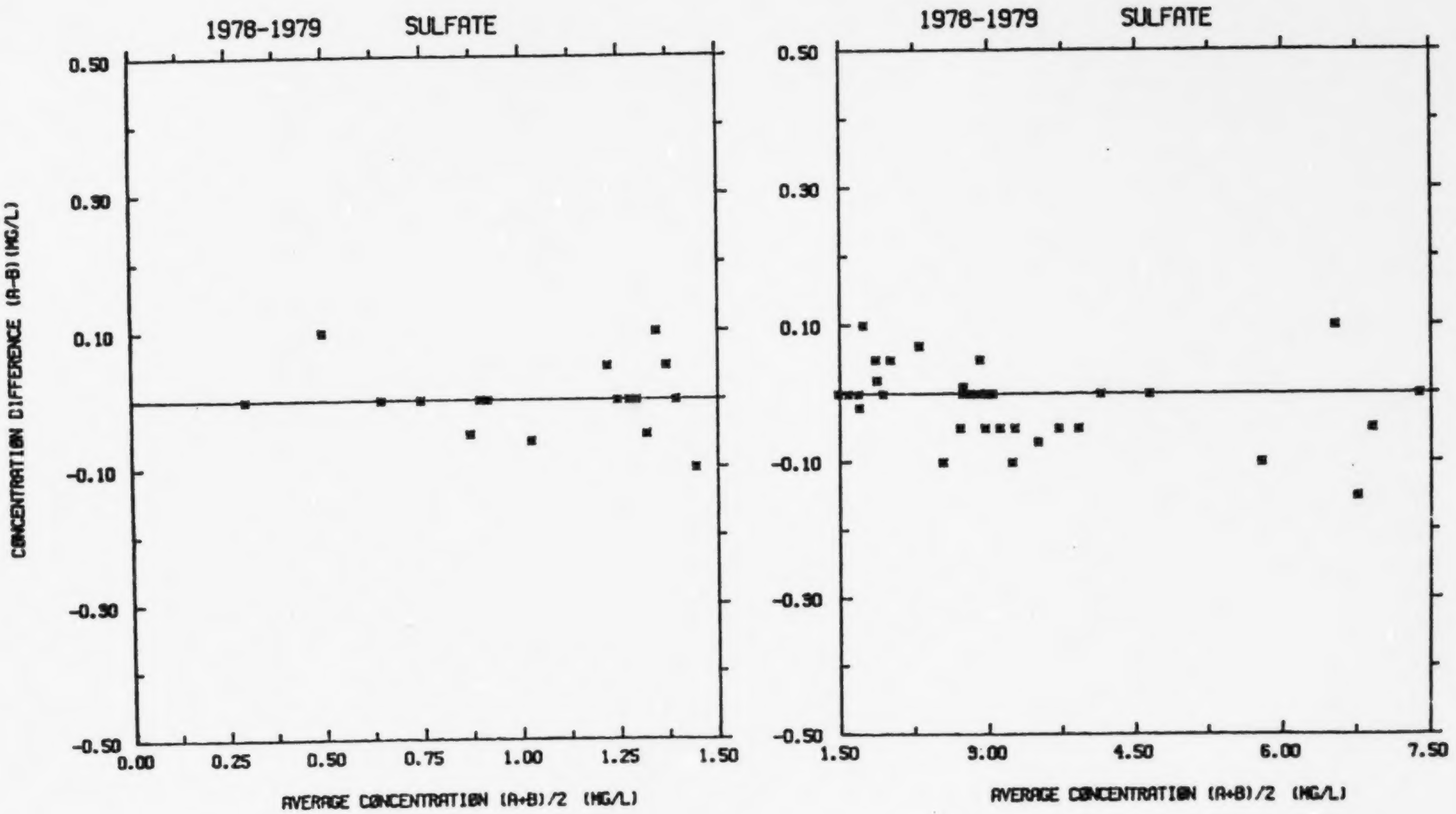


FIGURE 26. Replicate plots for sulfate for 1978 and 1979.

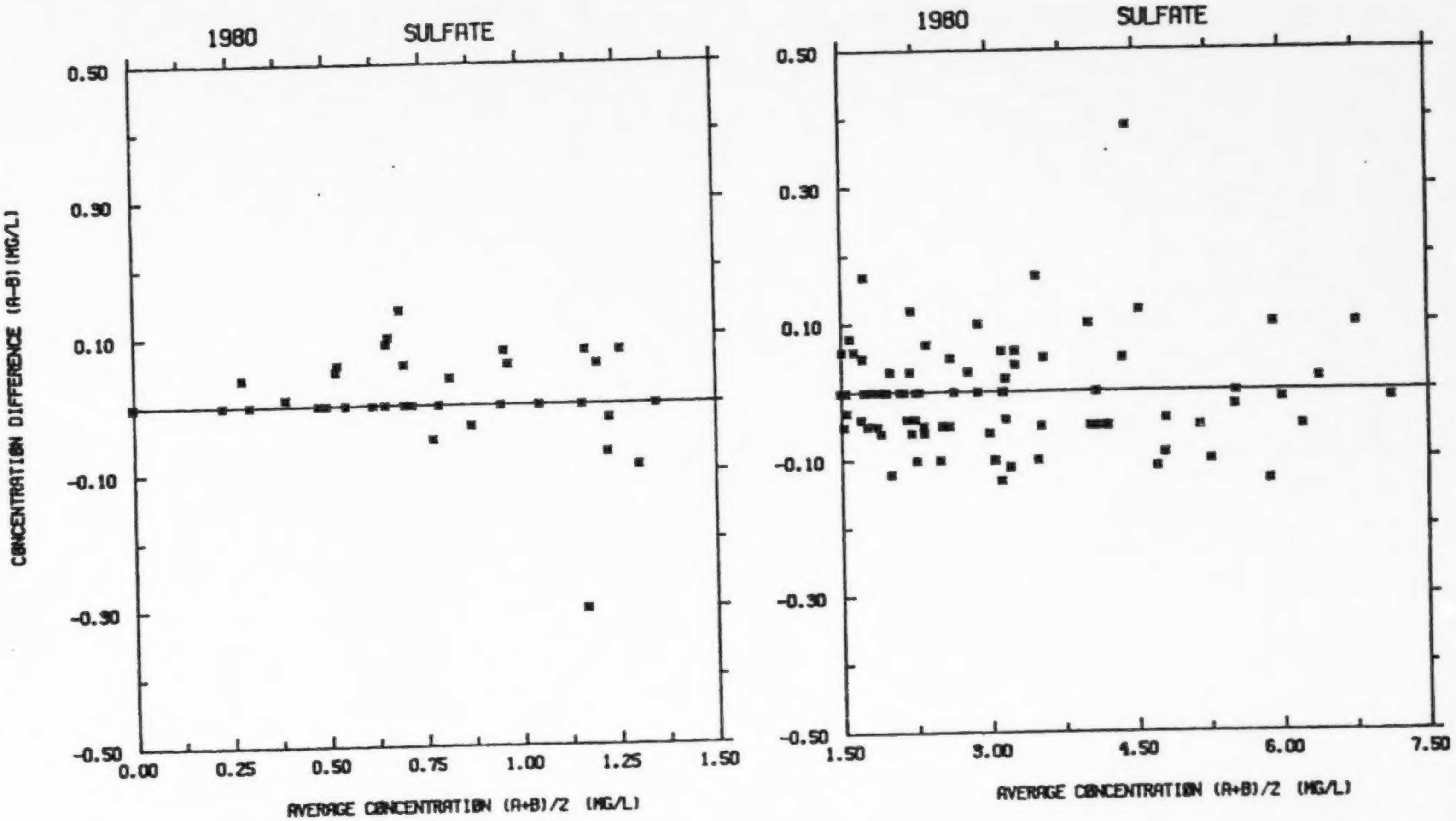


FIGURE 27. Replicate plots for sulfate for 1980.

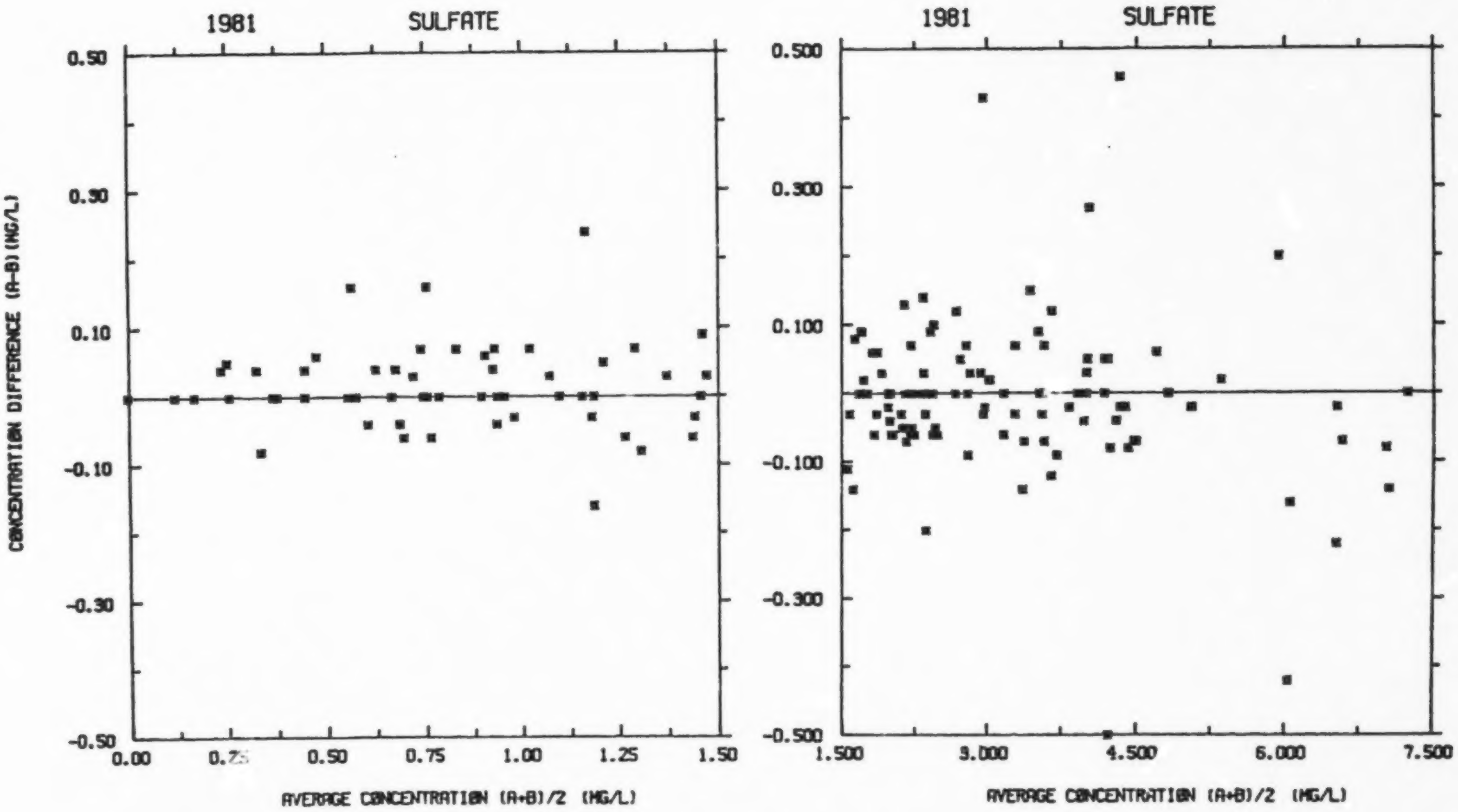


FIGURE 28. Replicate plots for sulfate for 1981.

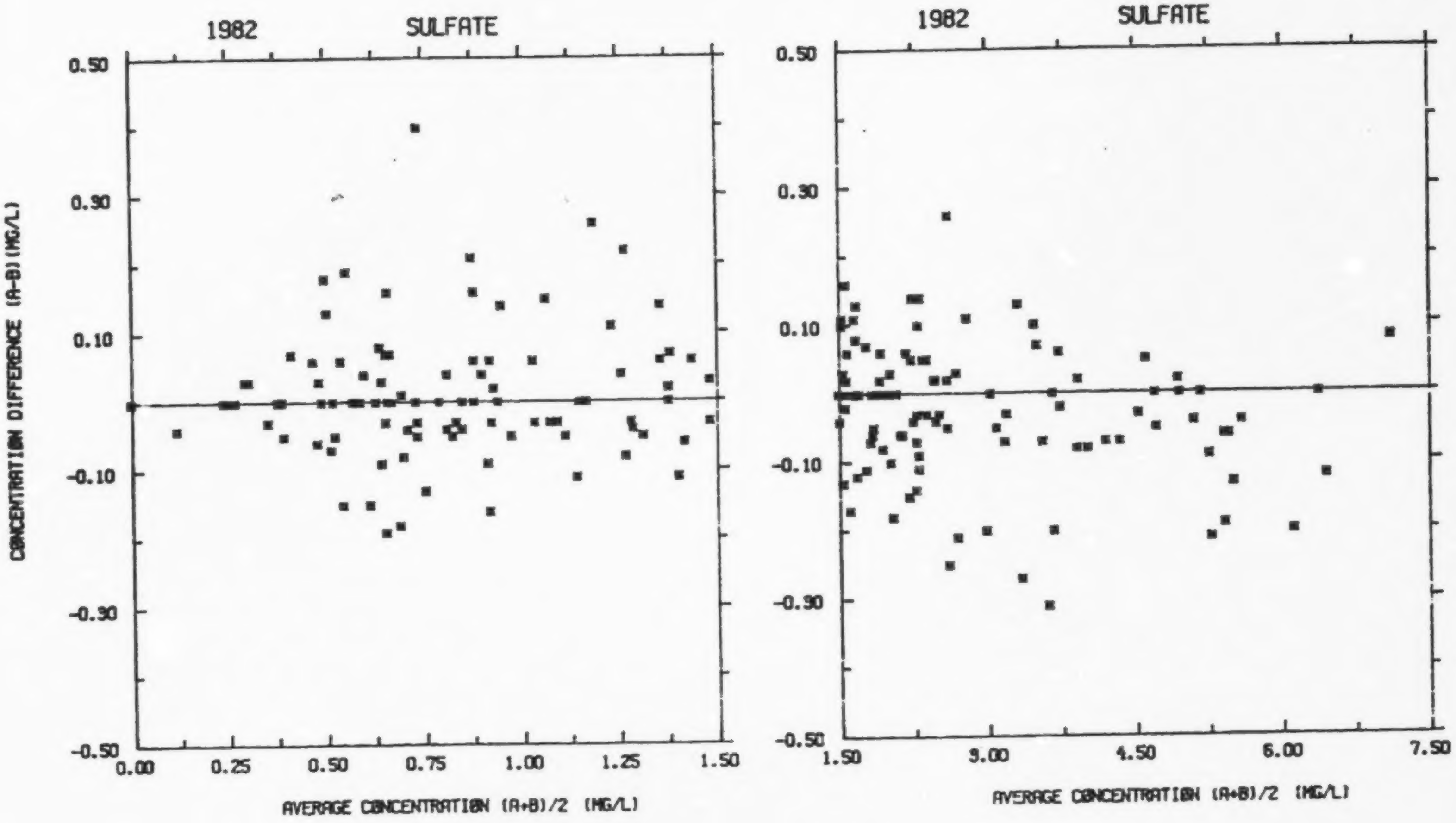


FIGURE 29. Replicate plots for sulfate for 1982.

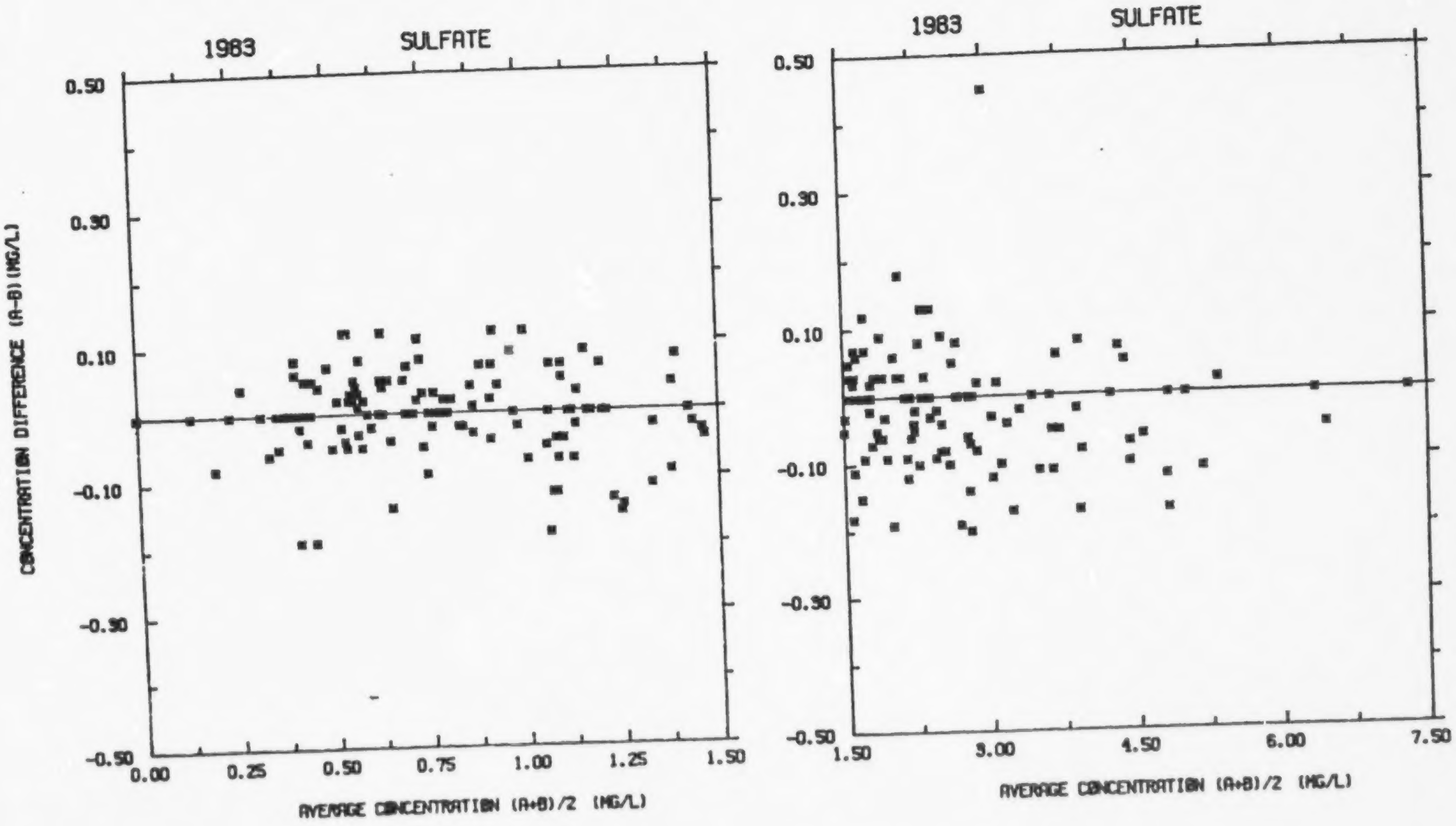


FIGURE 30. Replicate plots for sulfate for 1983.

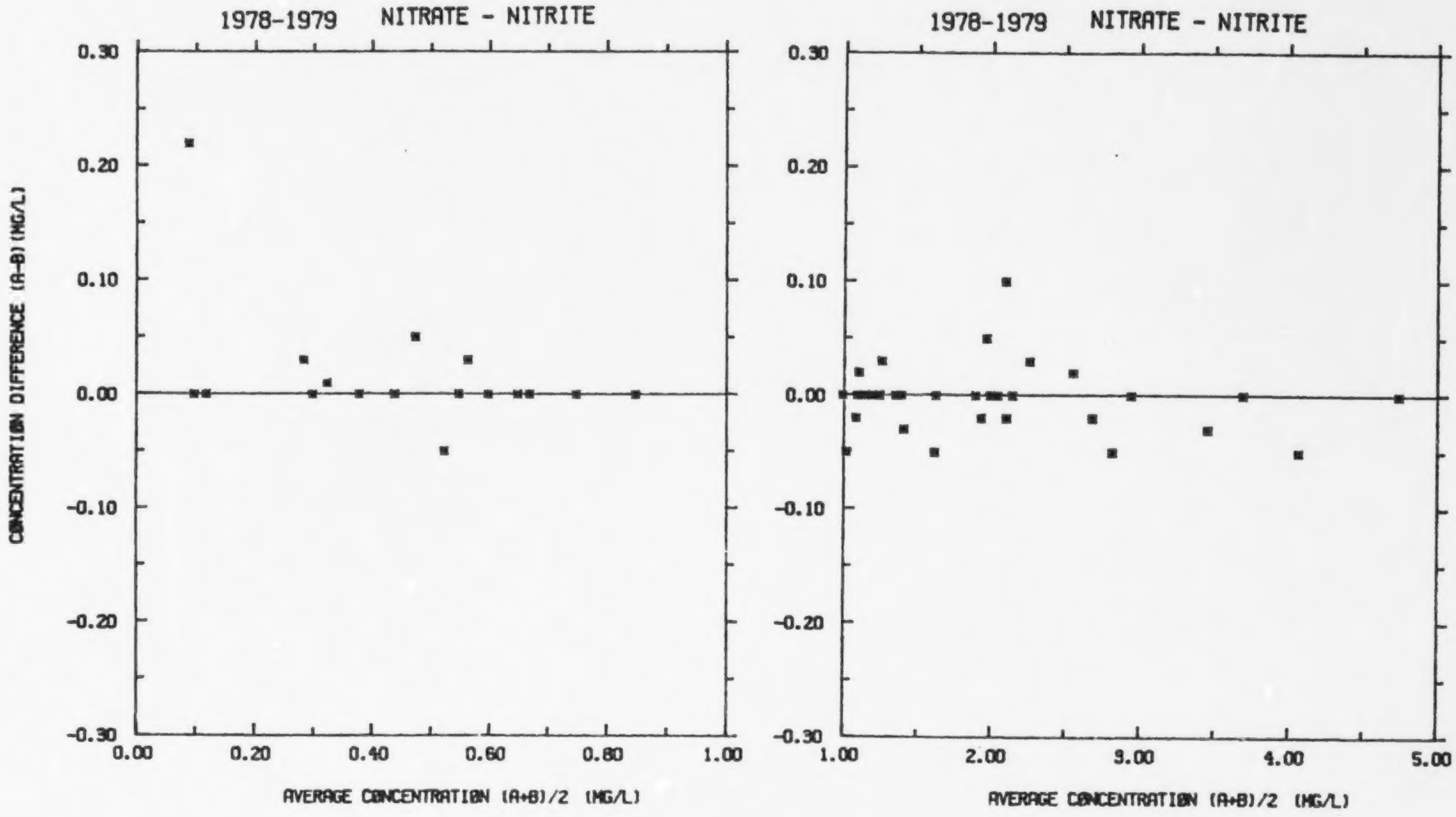


FIGURE 31. Replicate plots for nitrate-nitrite for 1978 and 1979.

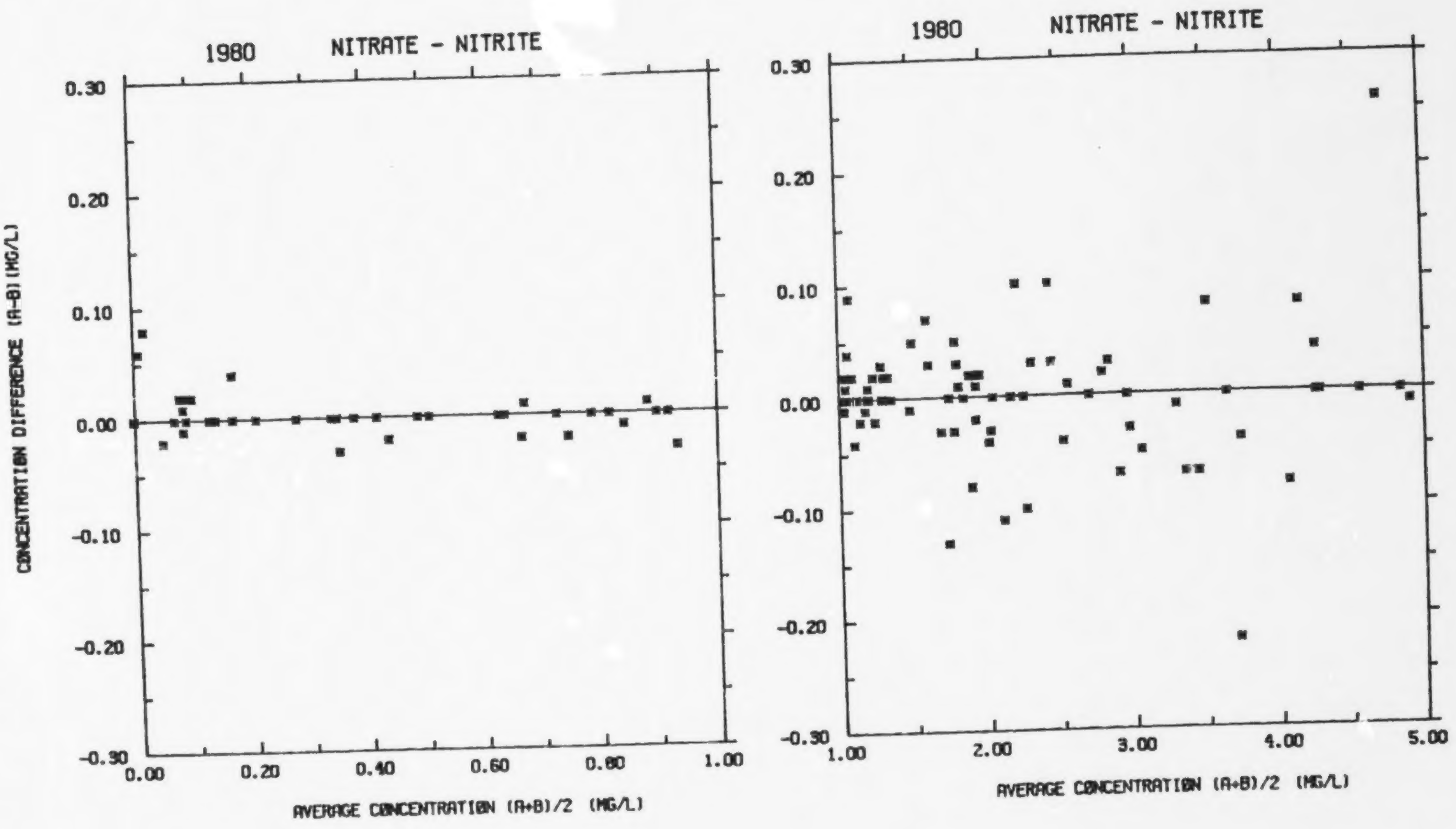


FIGURE 32. Replicate plots for nitrate-nitrite for 1980.

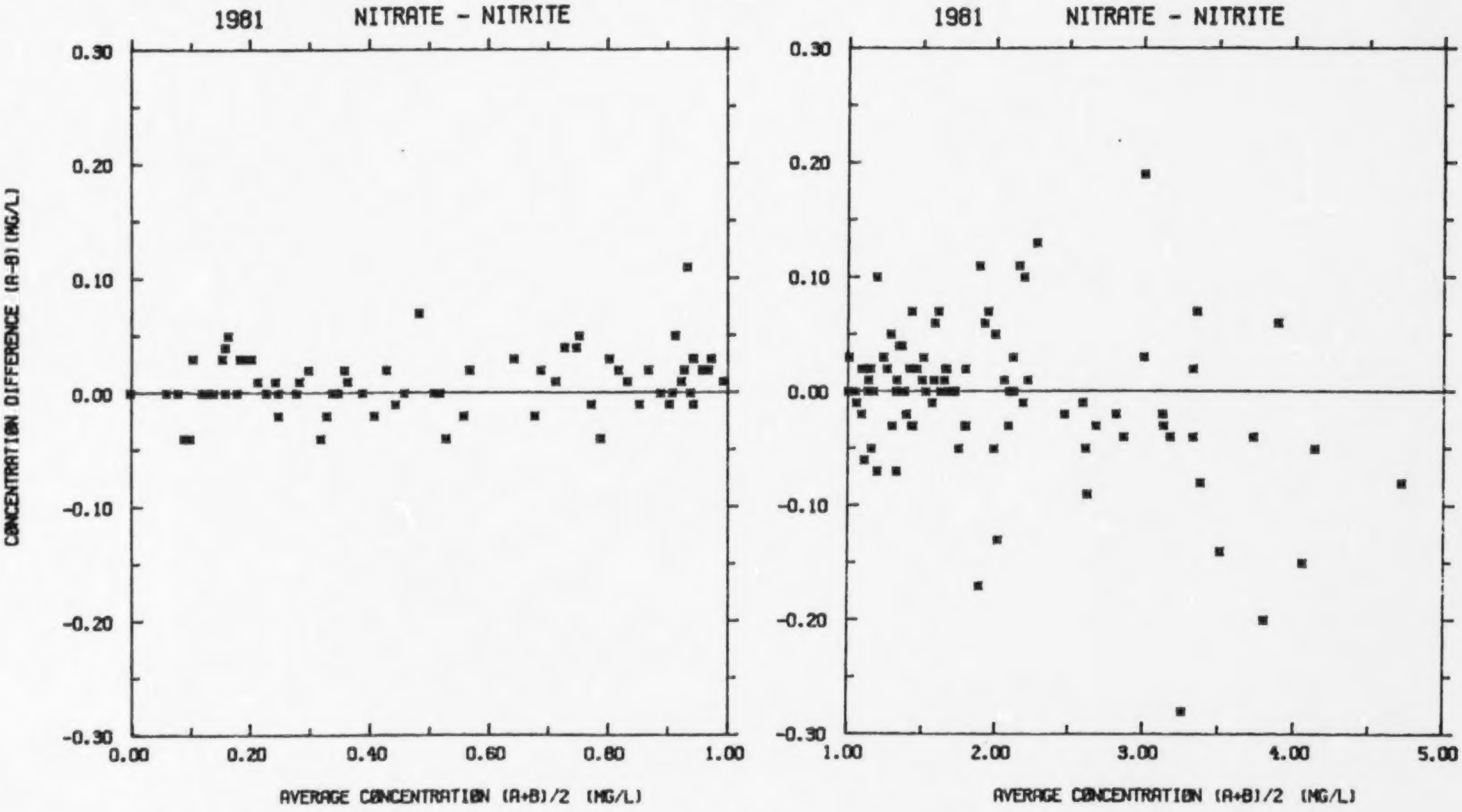


FIGURE 33. Replicate plots for nitrate-nitrite for 1981.

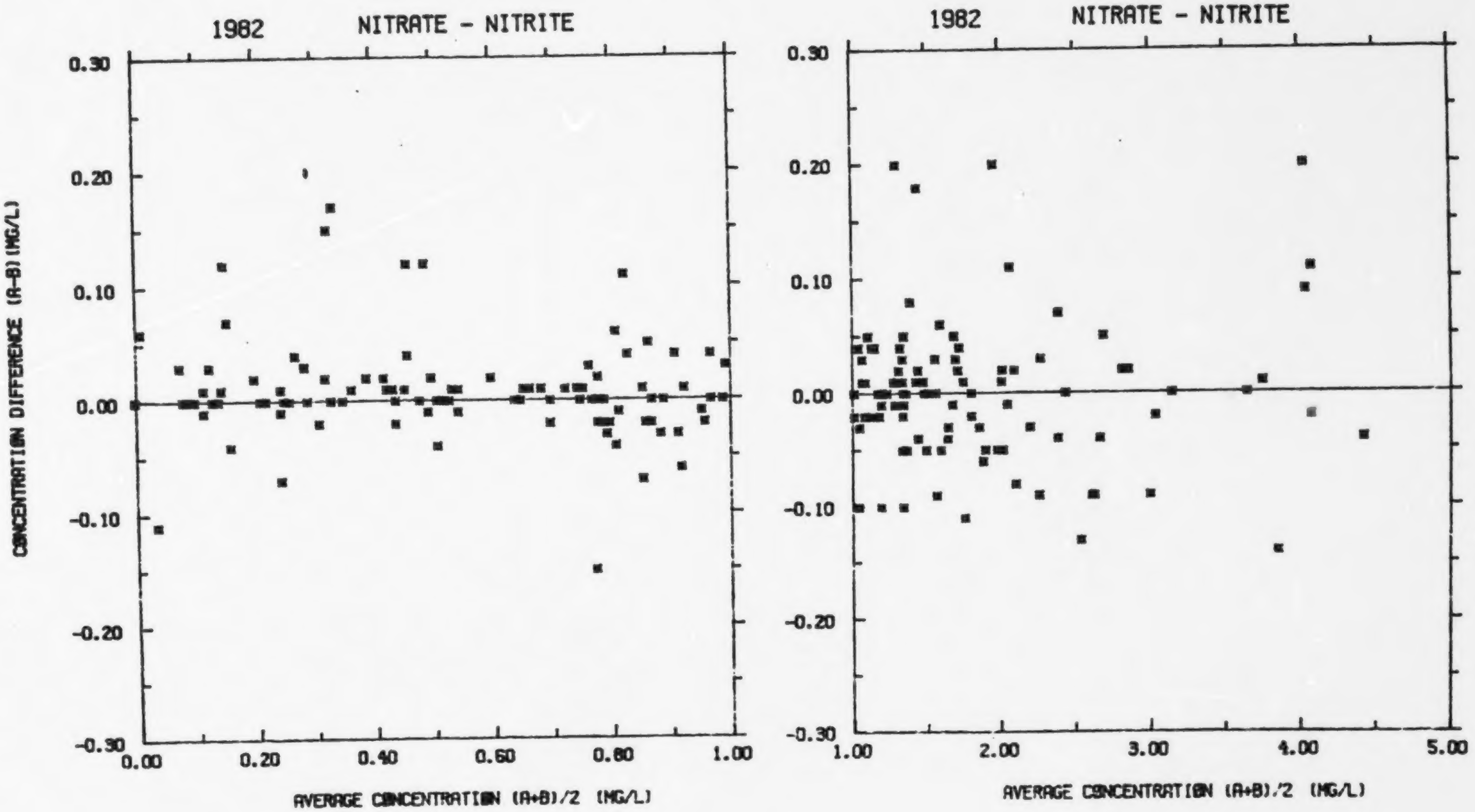


FIGURE 34. Replicate plots for nitrate-nitrite for 1982.

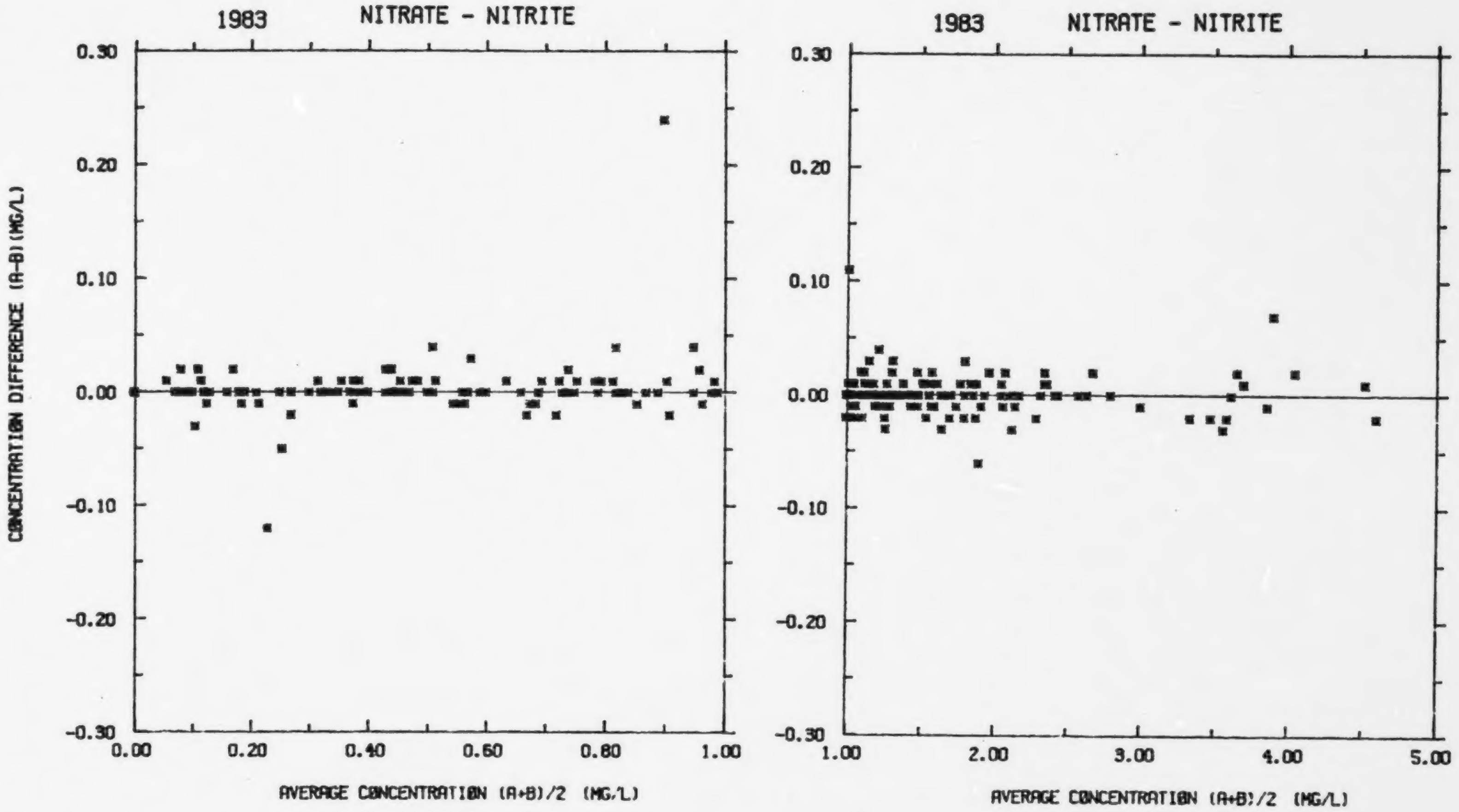


FIGURE 35. Replicate plots for nitrate-nitrite for 1983.

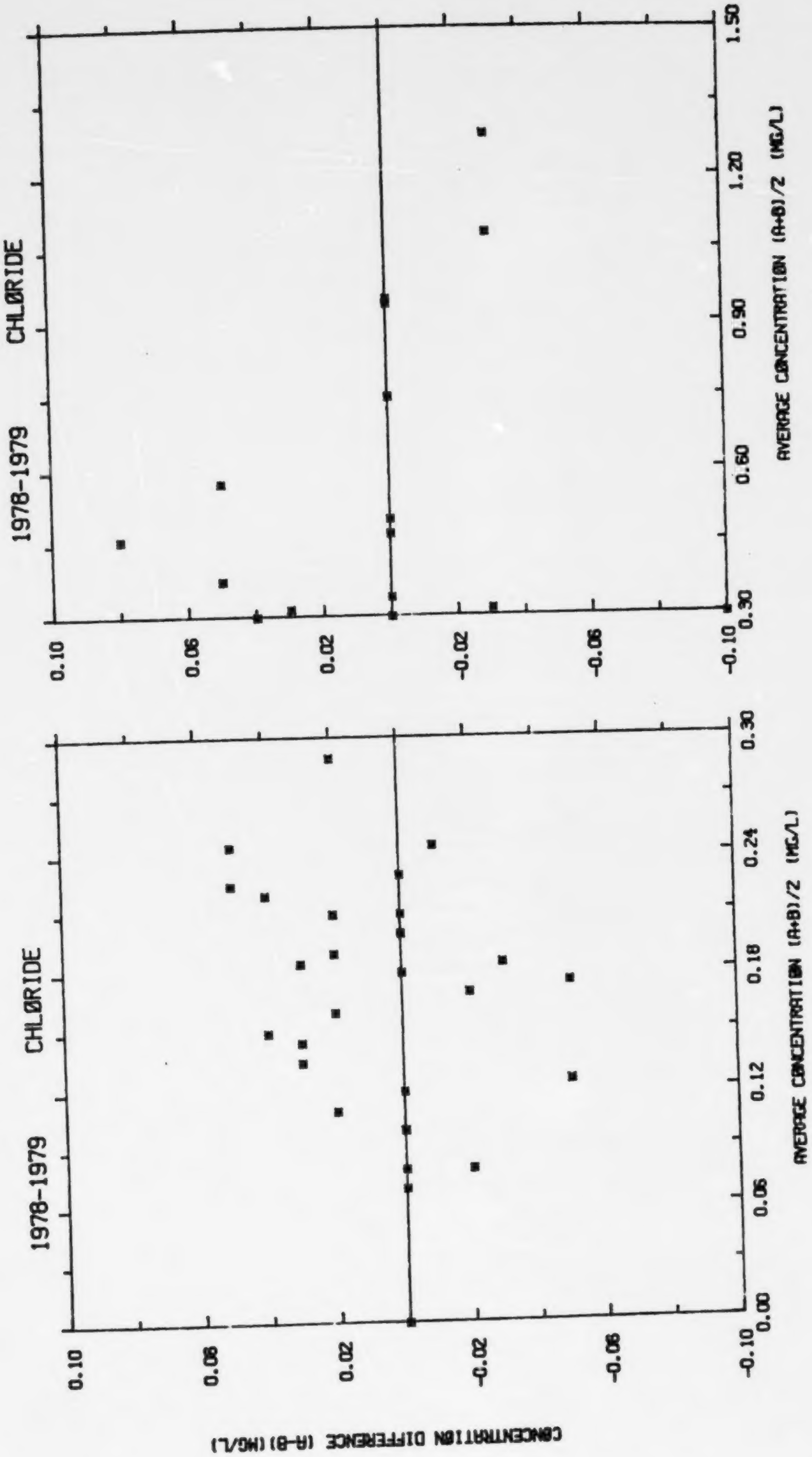


FIGURE 36. Replicate plots for chloride for 1978 and 1979.

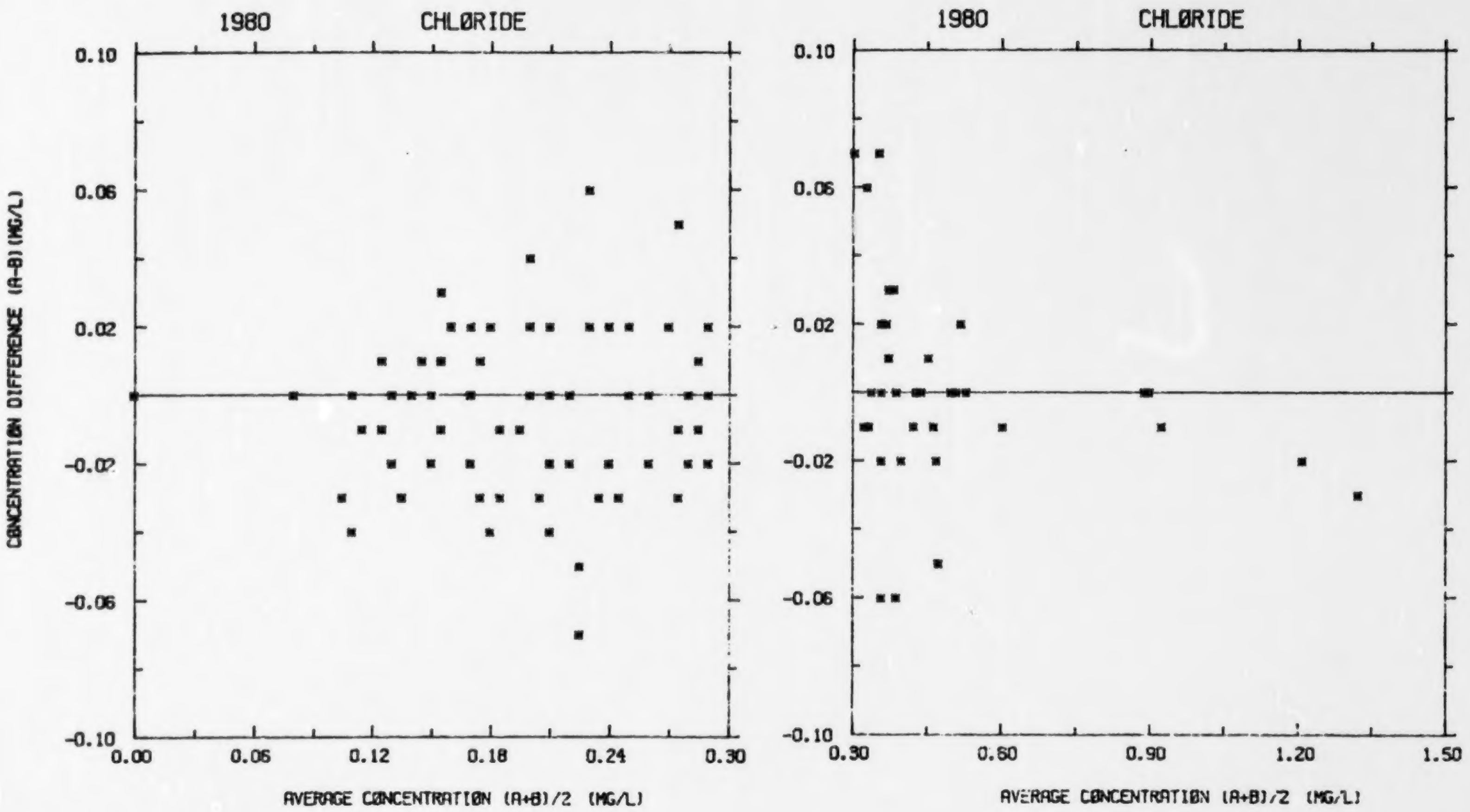


FIGURE 37. Replicate plots for chloride for 1980.

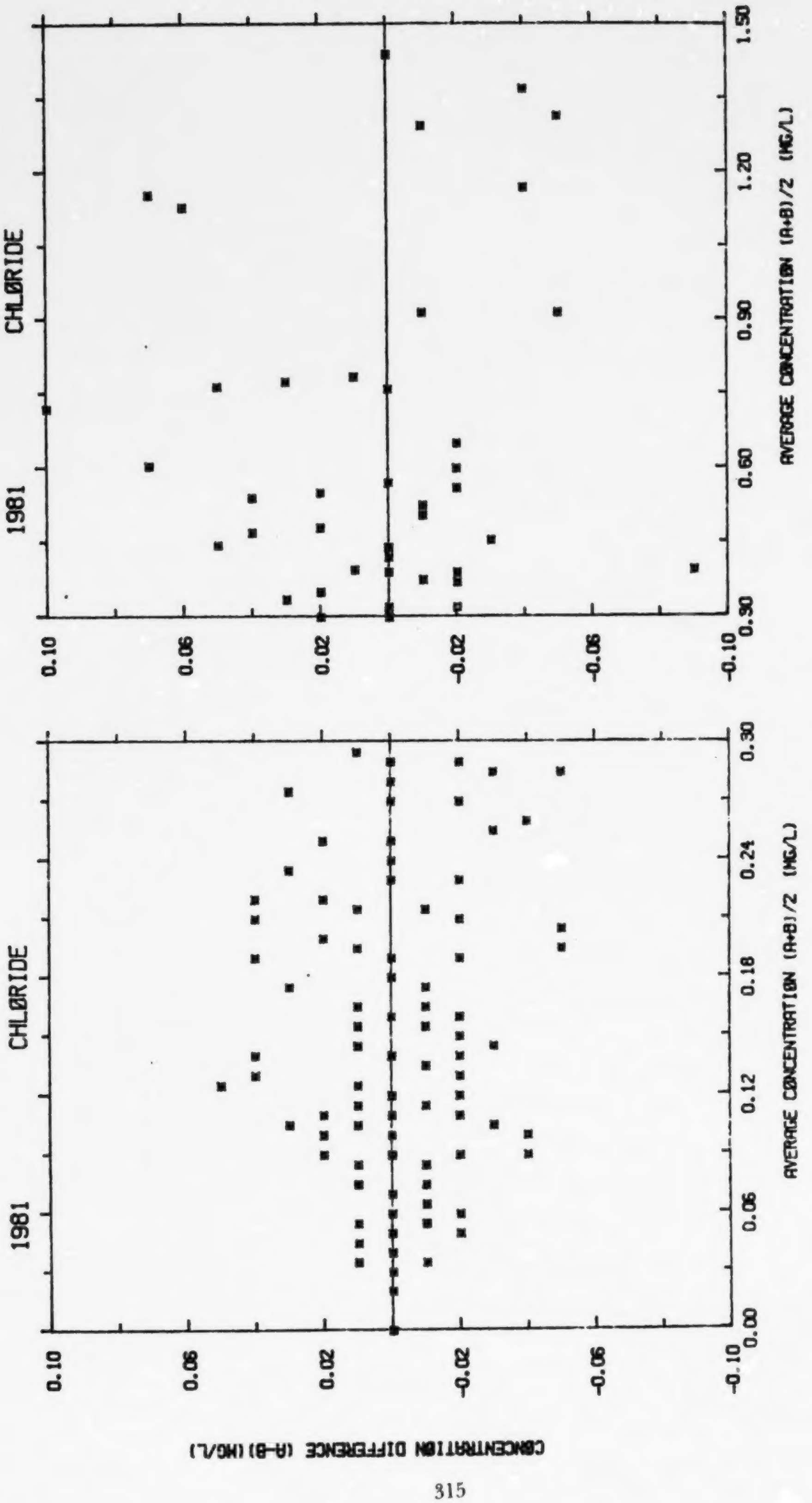


FIGURE 38. Replicate plots for chloride for 1981.

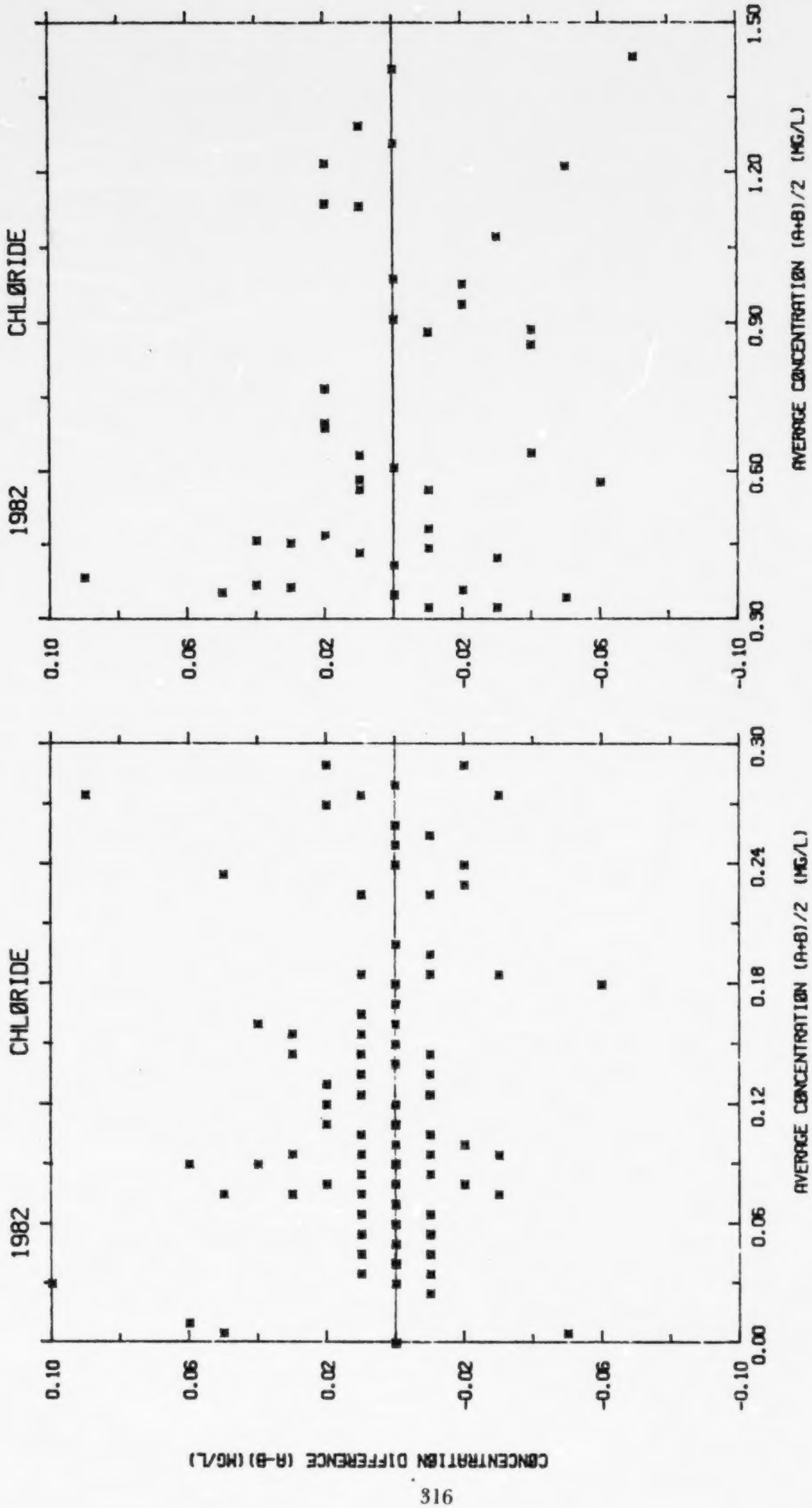


FIGURE 39. Replicate plots for chloride for 1982.

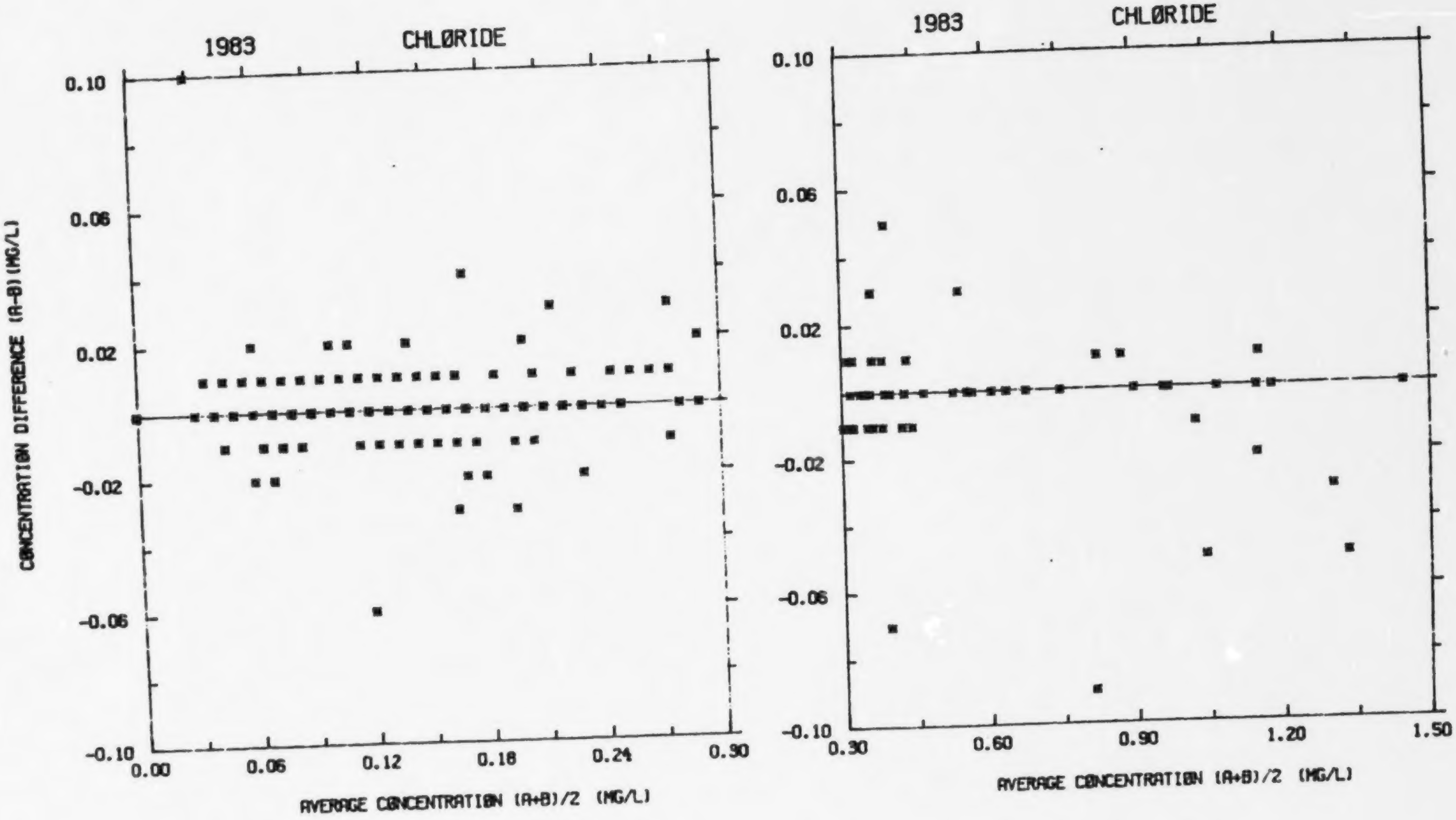


FIGURE 40. Replicate plots for chloride for 1983.

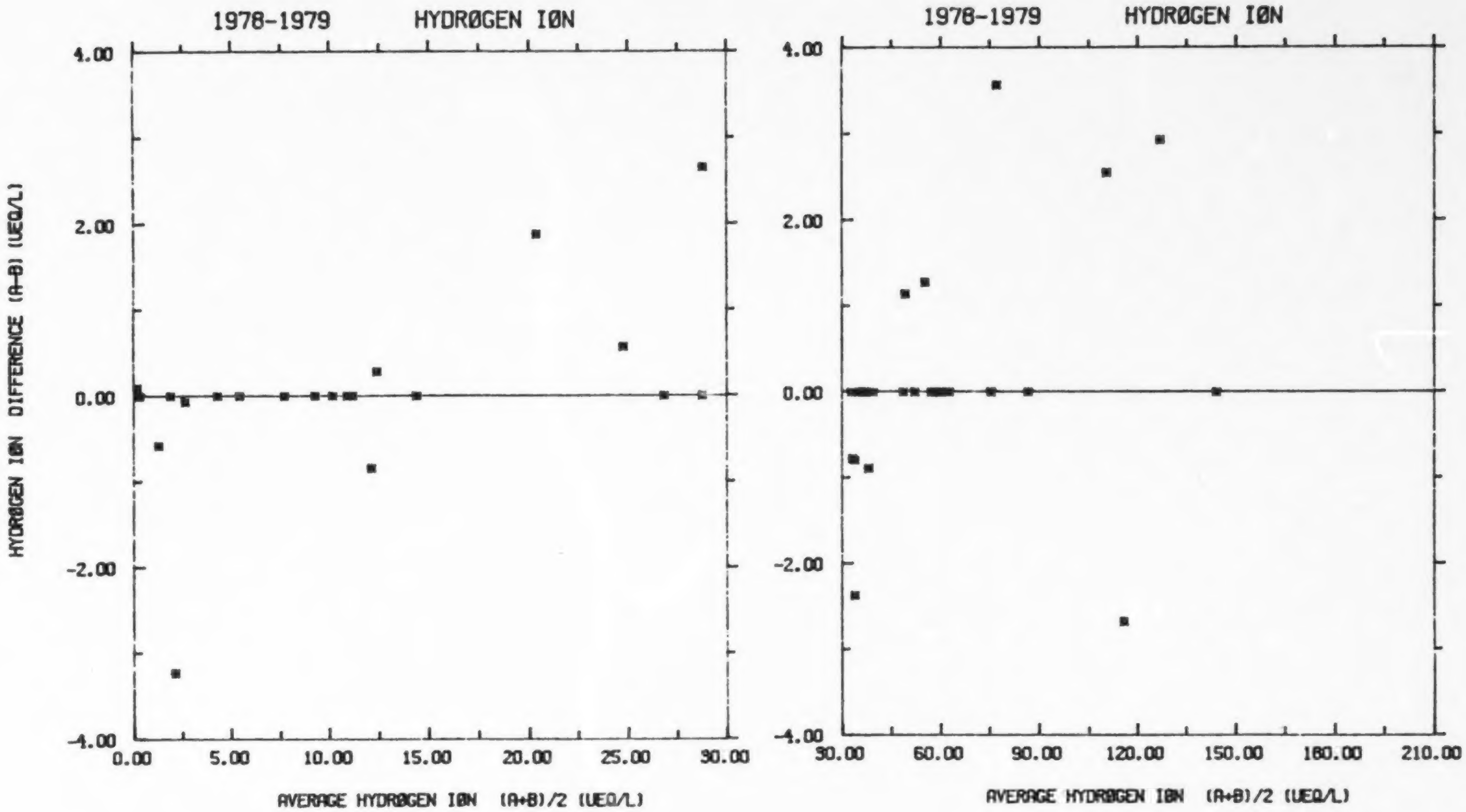


FIGURE 41. Replicate plots for hydrogen ion concentration for 1978 and 1979.

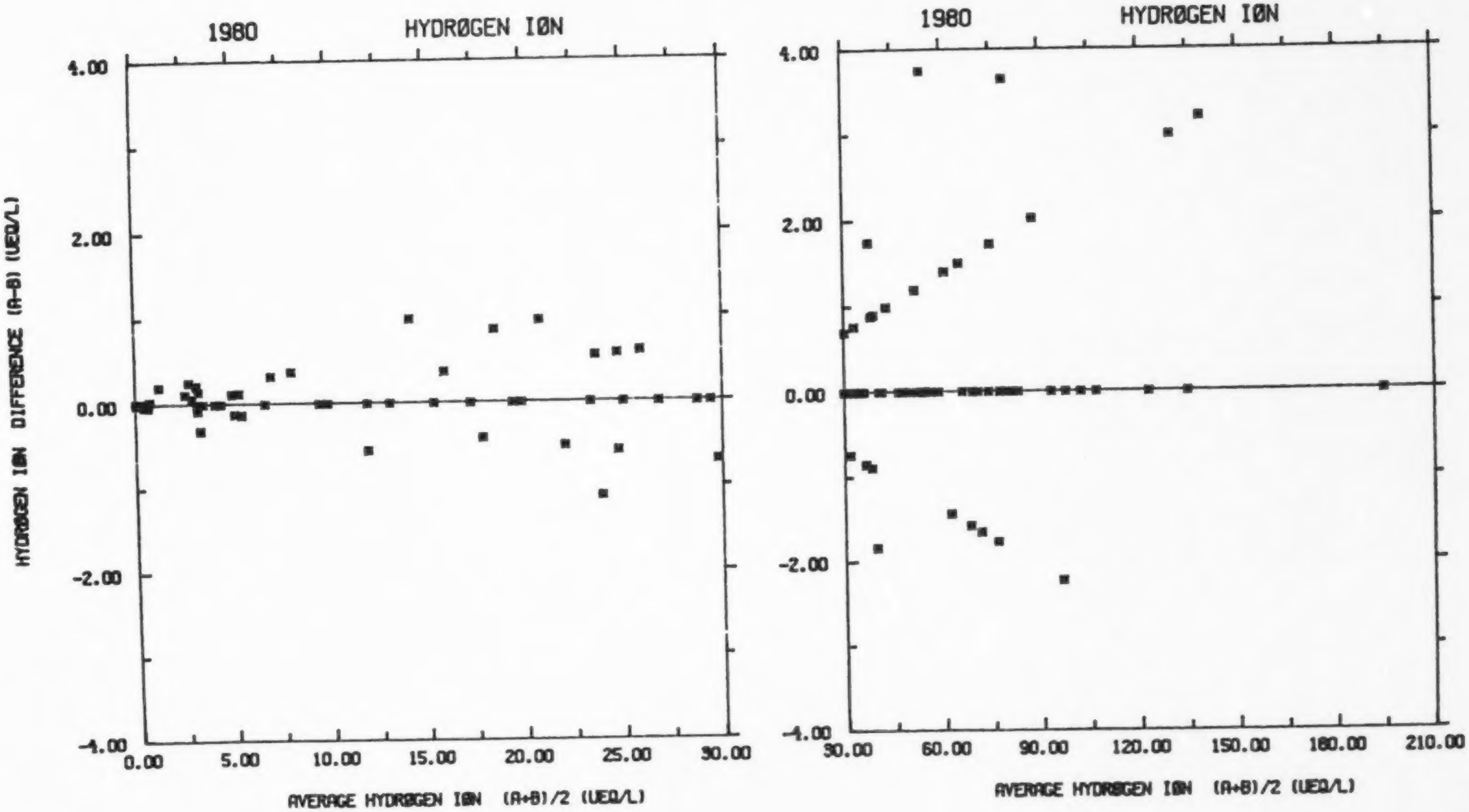


FIGURE 42. Replicate plots for hydrogen ion concentration for 1980.

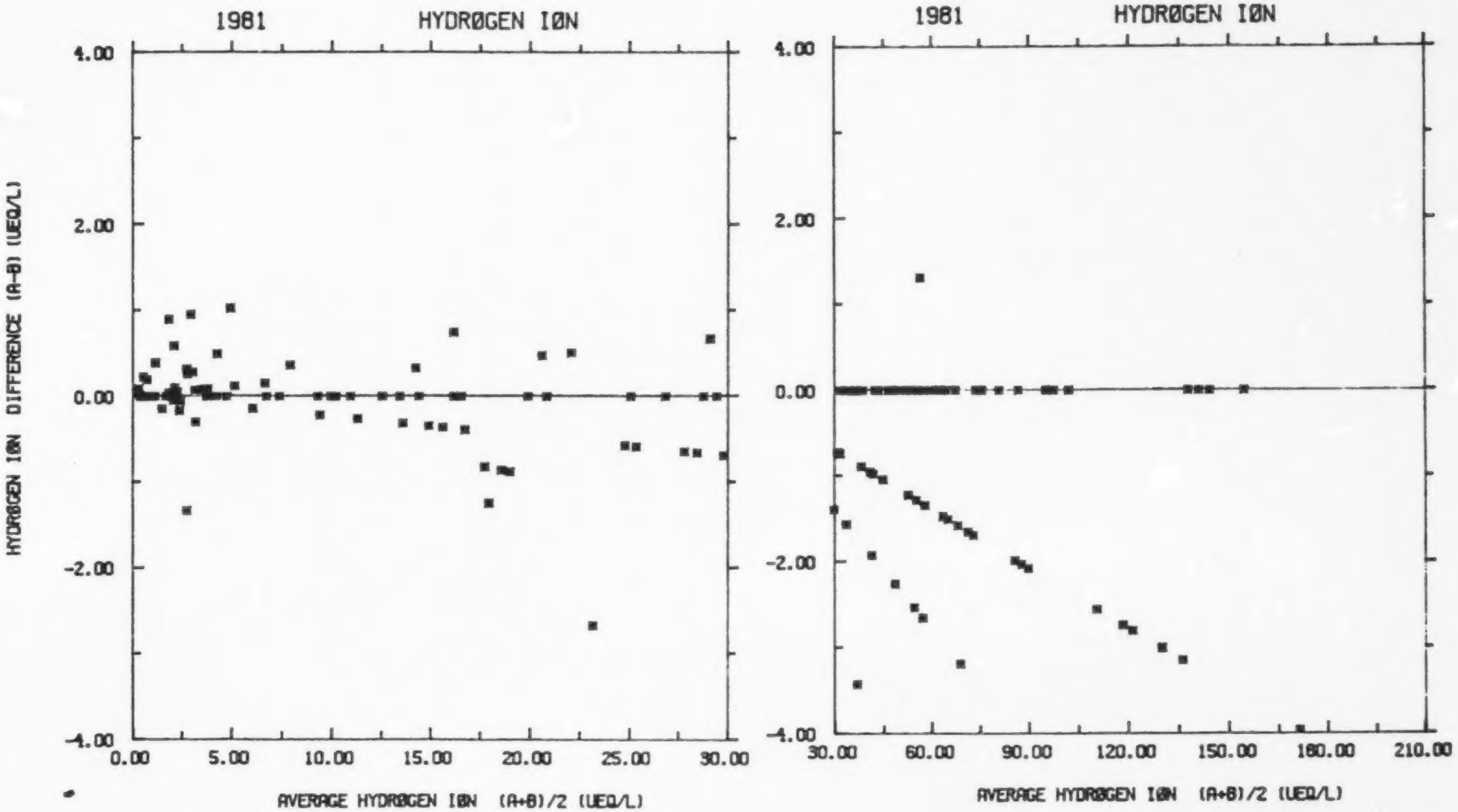


FIGURE 43. Replicate plots for hydrogen ion concentration for 1981.

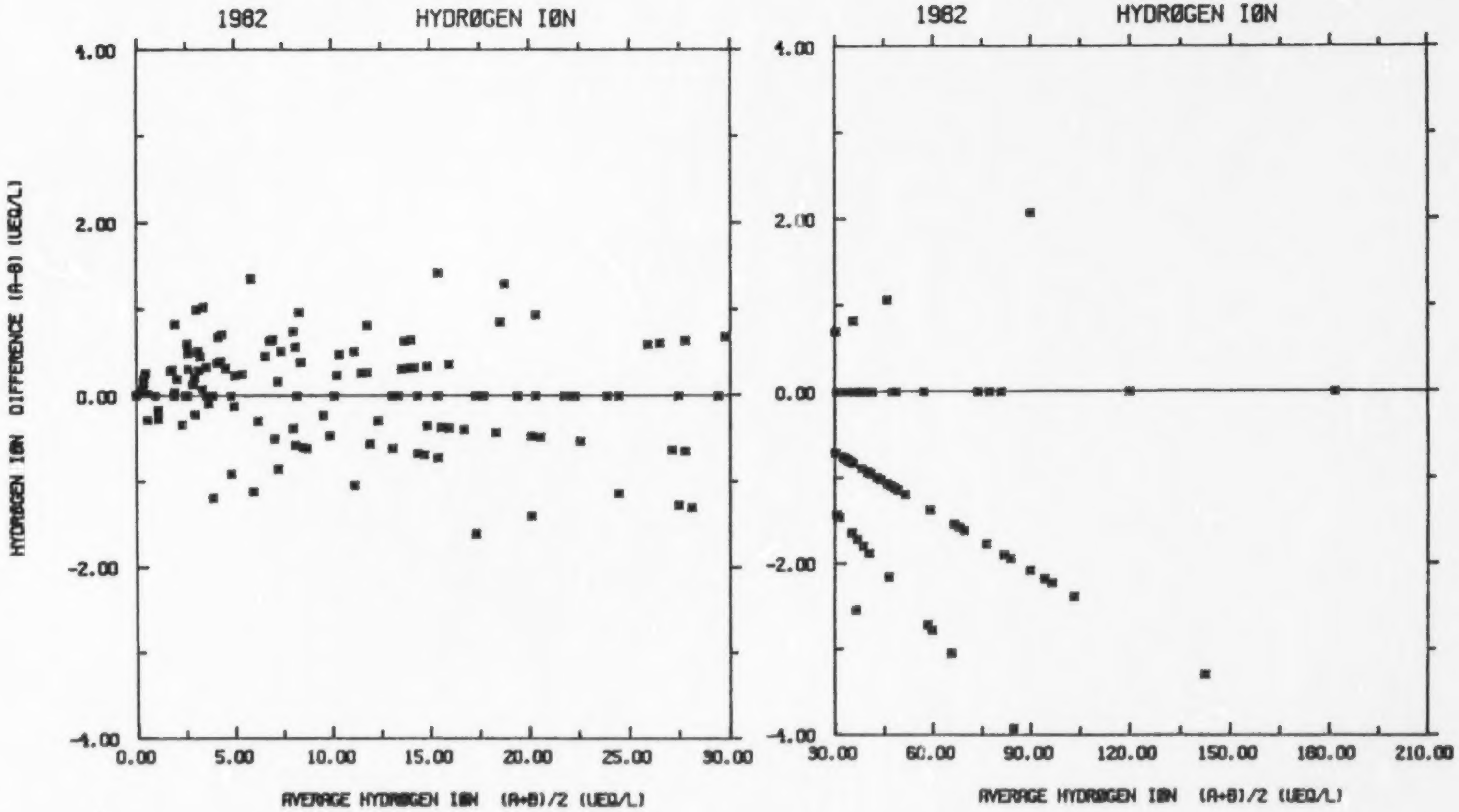


FIGURE 44. Replicate plots for hydrogen ion concentration for 1982.

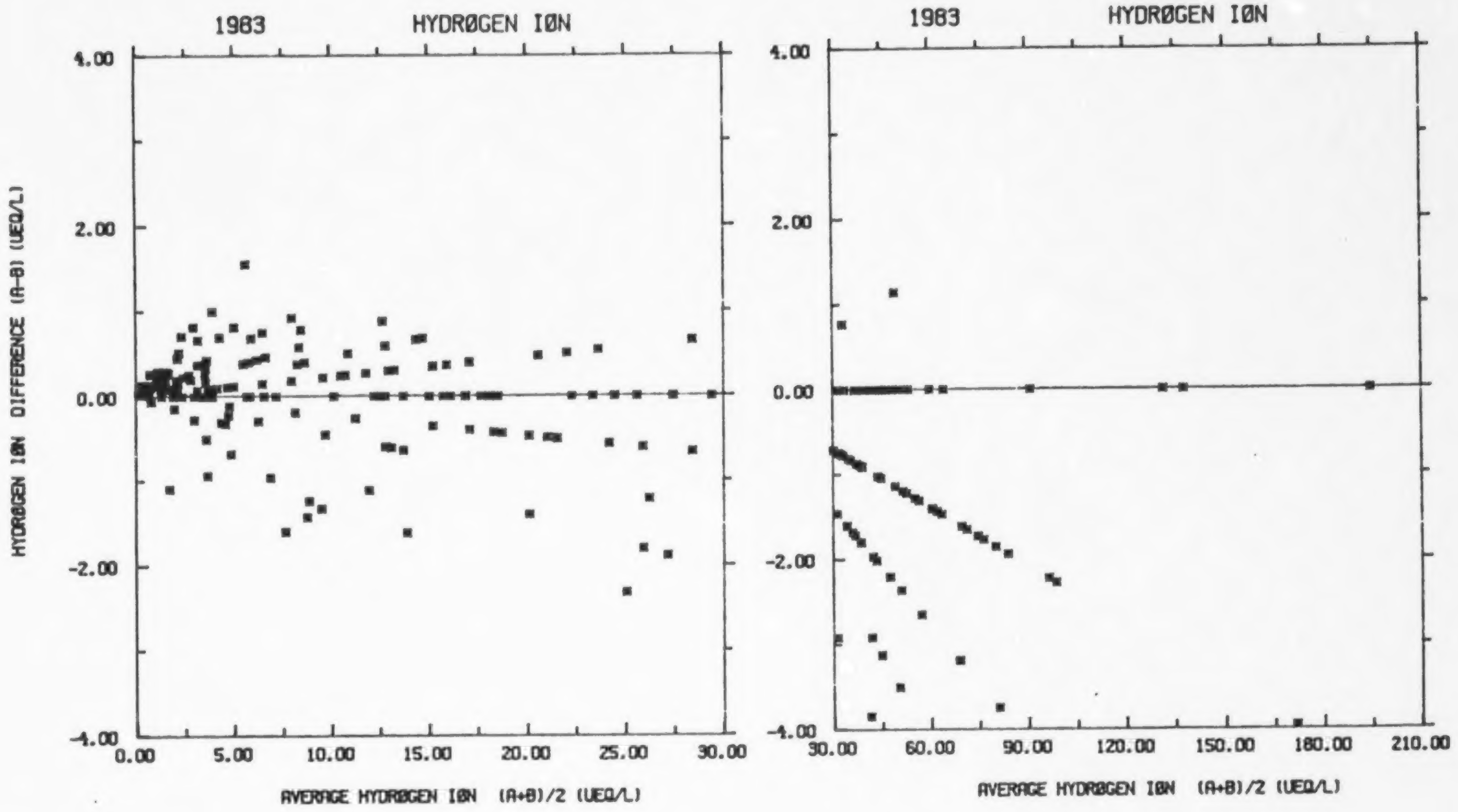


FIGURE 45. Replicate plots for hydrogen ion concentration for 1983.

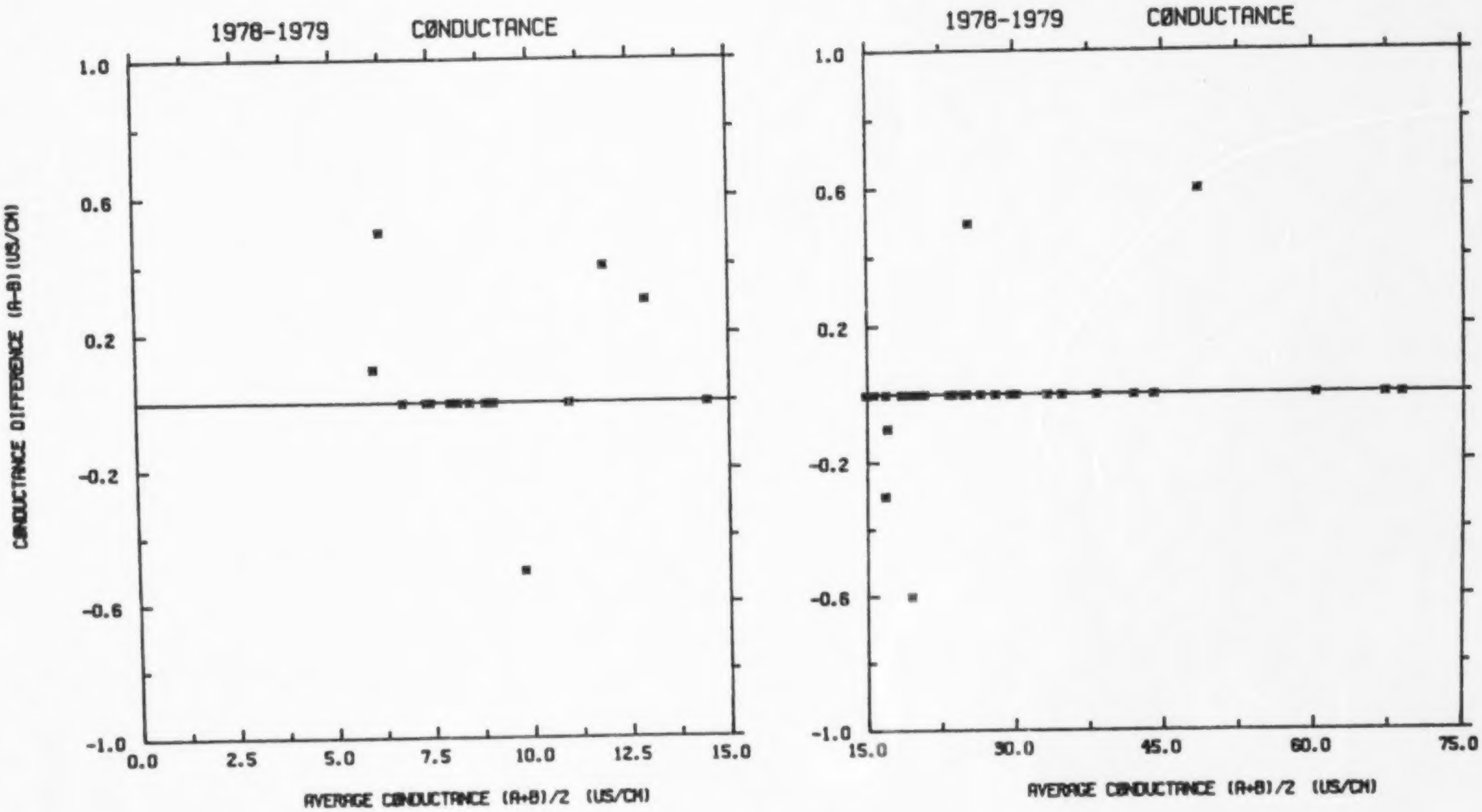


FIGURE 46. Replicate plots for specific conductance for 1978 and 1979.

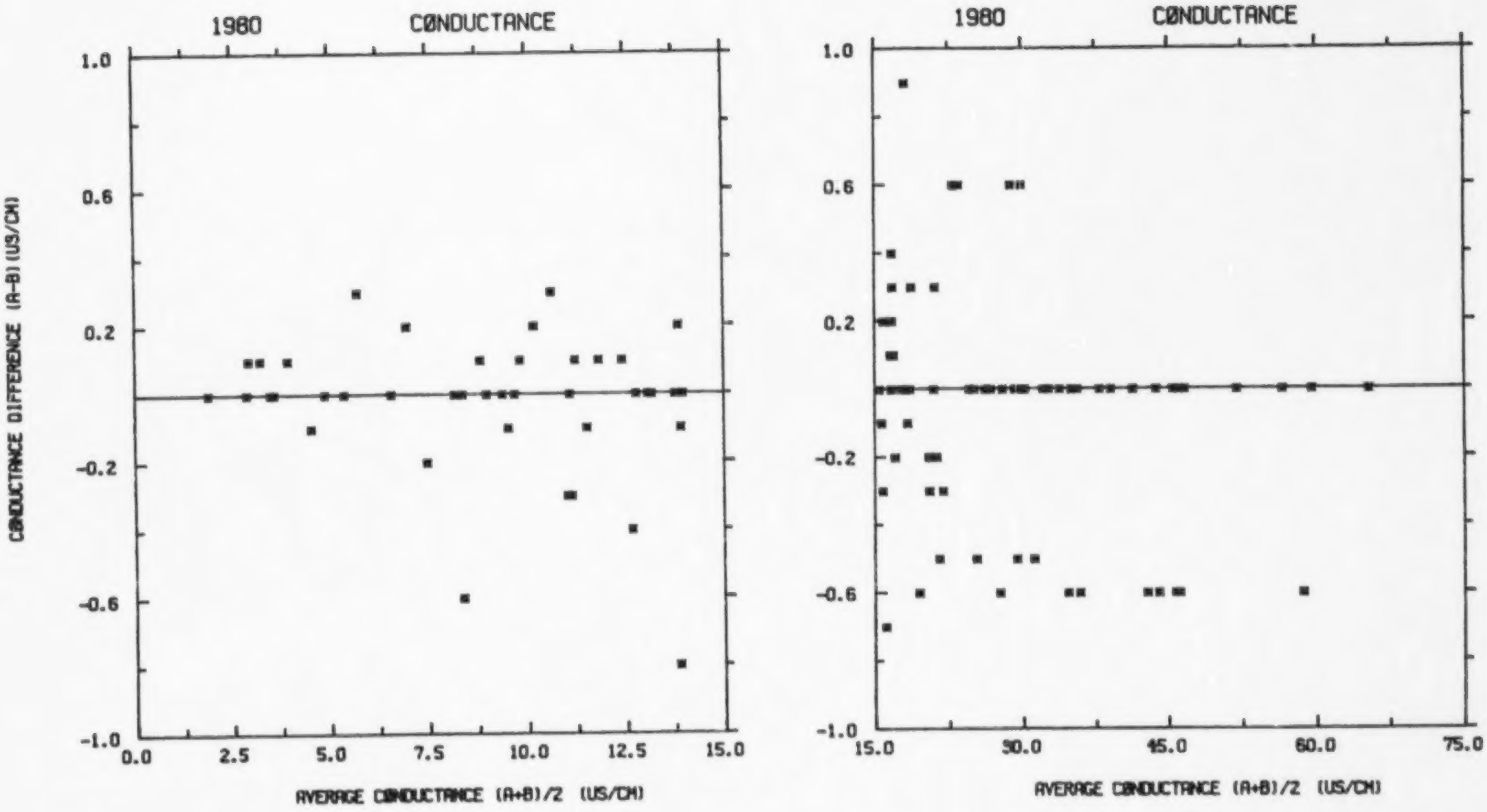


FIGURE 47. Replicate plots for specific conductance for 1980.

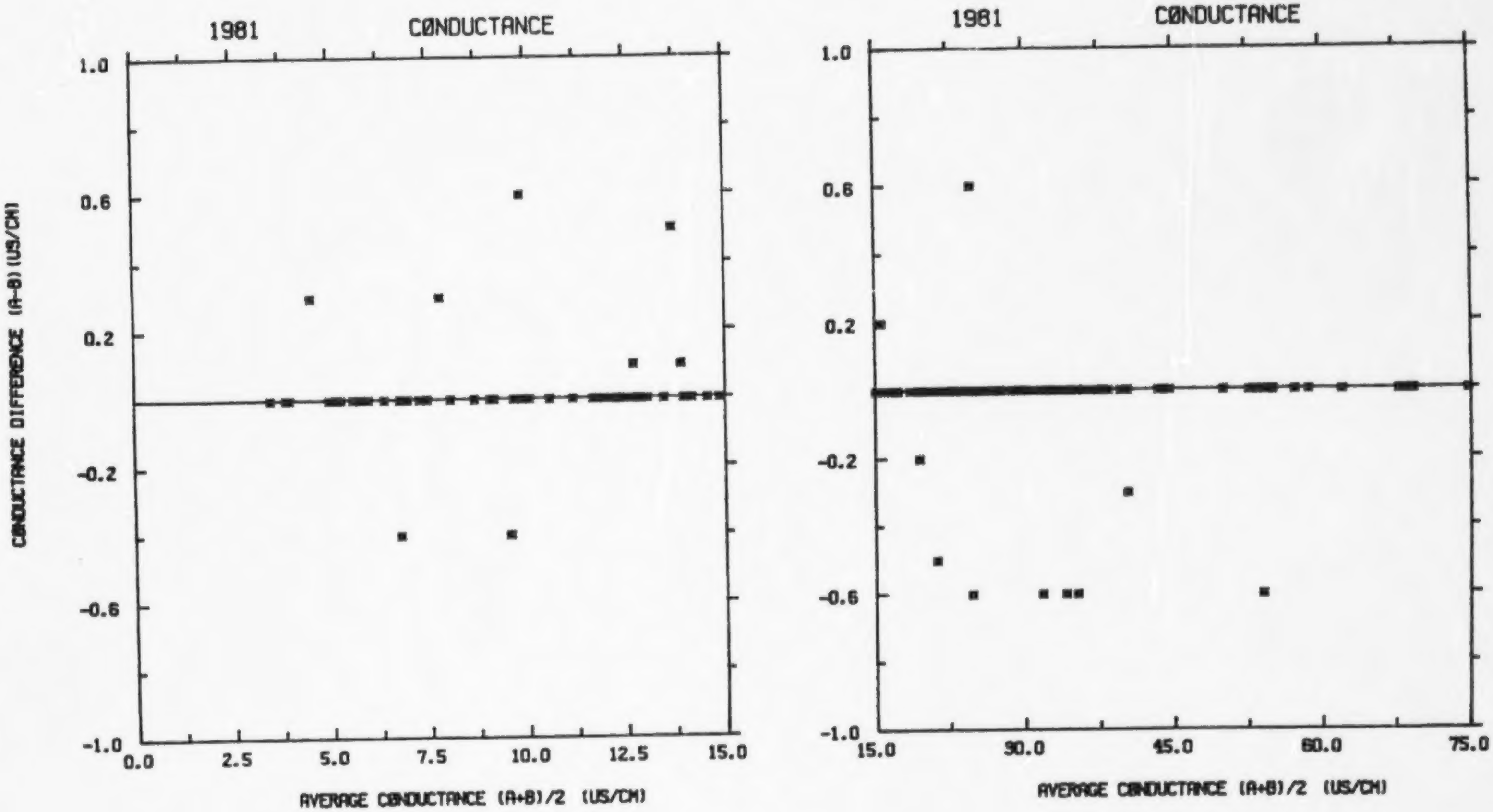


FIGURE 48. Replicate plots for specific conductance for 1981.

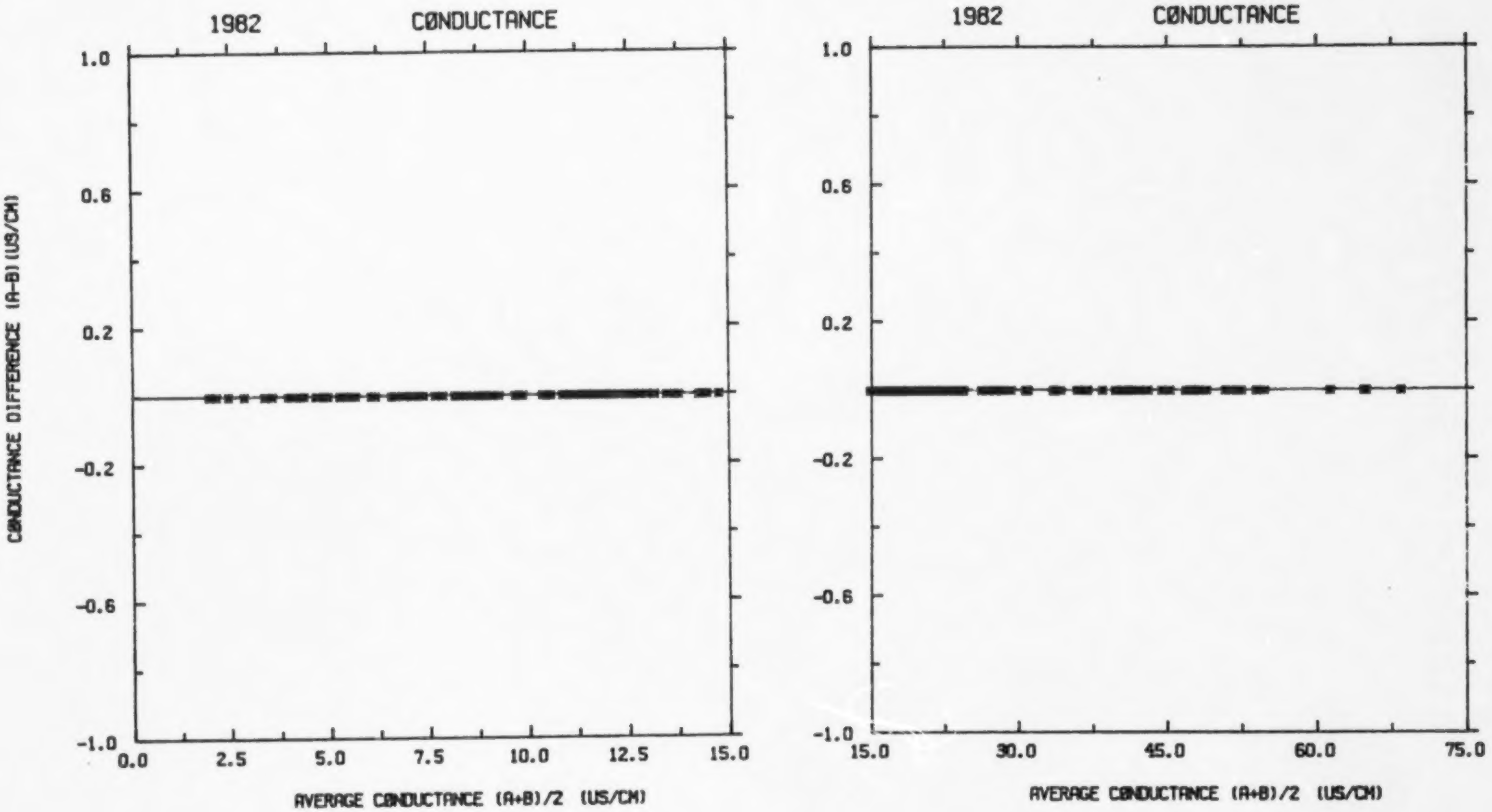


FIGURE 49. Replicate plots for specific conductance for 1982.

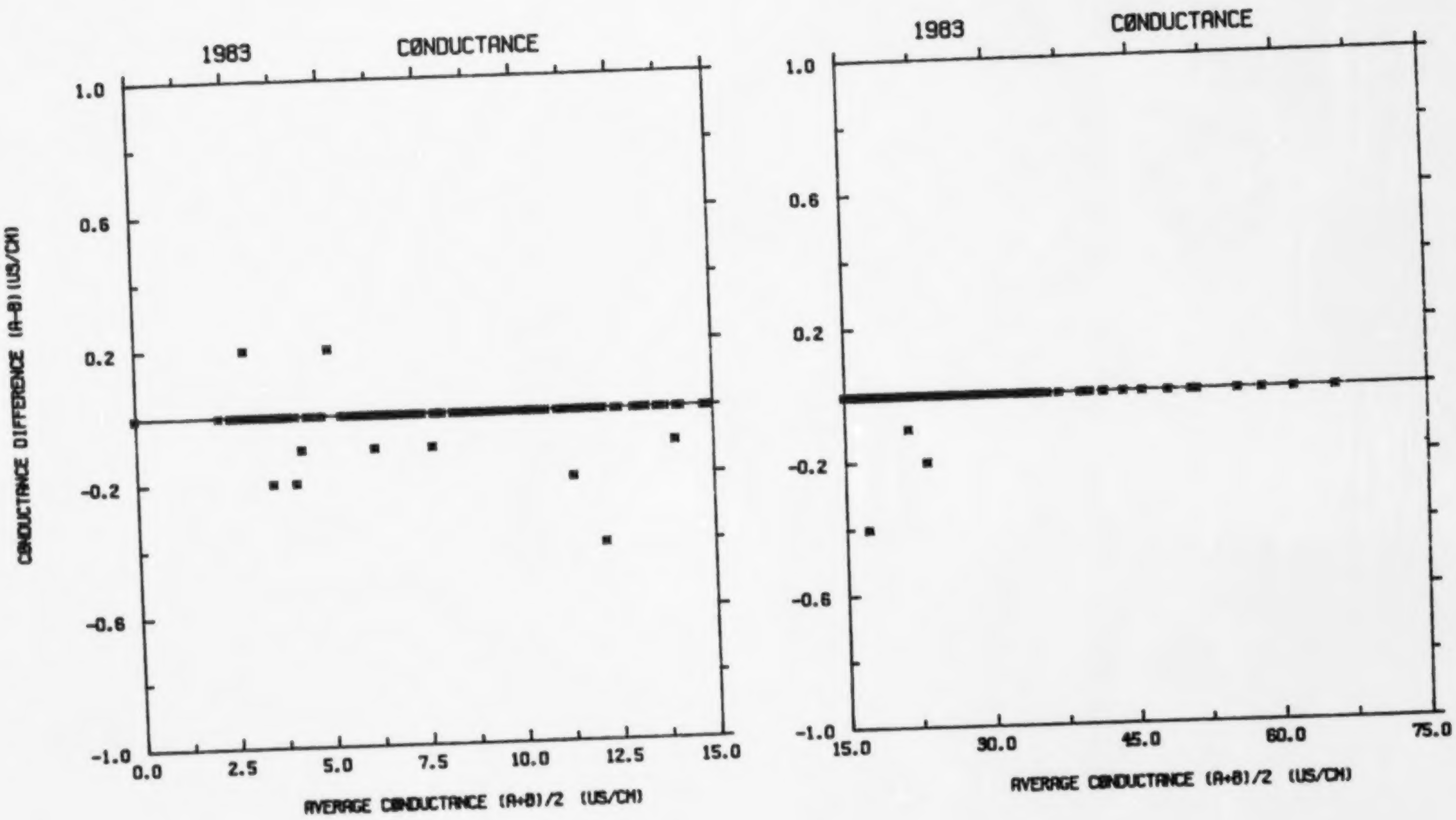


FIGURE 50. Replicate plots for specific conductance for 1983.

TABLE 1 (A-B) Data Summary for Replicate Analysis in 1978 and 1979.

Parameter	n[a]	Median Difference (mg/L)	Mean Difference (mg/L)	Standard Deviation (mg/L)
Calcium	54	0.000	0.001	0.006
Magnesium	54	0.000	0.000	0.001
Sodium	54	0.000	-0.001	0.005
Potassium	54	0.000	0.000	0.002
Ammonium	54	0.00	-0.01	0.02
Sulfate	54	0.00	0.00	0.08
Nitrate-Nitrite	54	0.00	0.00	0.04
Chloride	54	0.00	0.00	0.04
pH (units)	54	0.00	0.01	0.12
Specific Conductance (uS/cm)	54	0.0	-0.2	0.9

a. number of replicate pairs

TABLE 2 (A-B) Data Summary for Replicate Analysis in 1980.

Parameter	n[a]	Median Difference (mg/L)	Mean Difference (mg/L)	Standard Deviation (mg/L)
Calcium	125	0.000	0.000	0.008
Magnesium	125	0.000	0.000	0.001
Sodium	125	0.000	0.000	0.008
Potassium	125	0.000	0.000	0.002
Ammonium	125	0.00	0.00	0.01
Sulfate	125	0.00	0.00	0.08
Nitrate-Nitrite	125	0.00	0.00	0.06
Chloride	125	0.00	0.00	0.03
pH (units)	125	0.00	0.01	0.02
Specific Conductance (uS/cm)	125	0.0	-0.1	0.6

a. number of replicate pairs

TABLE 3 (A-B) Data Summary for Replicate Analysis in 1981.

Parameter	n[a]	Median Difference (mg/L)	Mean Difference (mg/L)	Standard Deviation (mg/L)
Calcium	175	0.000	0.000	0.009
Magnesium	175	0.000	0.000	0.002
Sodium	175	0.000	-0.001	0.005
Potassium	175	0.000	0.000	0.003
Ammonium	175	0.00	0.00	0.02
Sulfate	175	0.00	0.00	0.10
Nitrate-Nitrite	175	0.00	0.00	0.06
Chloride	175	0.00	0.00	0.03
pH (units)	175	0.00	-0.01	0.05
Specific Conductance (uS/cm)	175	0.0	0.0	0.3

a. number of replicate pairs

TABLE 4 (A-B) Data Summary for Replicate Analysis in 1982.

Parameter	n[a]	Median Difference (mg/L)	Mean Difference (mg/L)	Standard Deviation (mg/L)
Calcium	212	0.000	-0.001	0.007
Magnesium	212	0.000	0.000	0.002
Sodium	212	0.000	0.000	0.012
Potassium.	212	0.000	0.000	0.003
Ammonium	212	0.00	0.00	0.02
Sulfate	212	0.00	-0.01	0.14
Nitrate-Nitrite	212	0.00	0.01	0.06
Chloride	212	0.00	0.00	0.03
pH (units)	212	0.00	0.00	0.04
Specific Conductance (uS/cm)	212	0.0	0.0	0.0

a. number of replicate pairs

TABLE 5 (A-B) Data Summary for Replicate Analysis in 1983.

Parameter	n[a]	Median Difference (mg/L)	Mean Difference (mg/L)	Standard Deviation (mg/L)
Calcium	255	0.001	0.001	0.008
Magnesium	255	0.000	0.000	0.002
Sodium	255	0.000	0.001	0.019
Potassium	255	0.000	0.000	0.002
Ammonium	255	0.00	0.01	0.05
Sulfate	255	0.00	-0.01	0.08
Nitrate-Nitrite	255	0.00	0.00	0.09
Chloride	255	0.00	0.00	0.07
pH (units)	255	0.00	-0.01	0.04
Specific Conductance (uS/cm)	255	0.0	0.0	0.1

a. number of replicate pairs